

Galway County Council

Five years annual monitoring of Rahasane Turlough

Final report on monitoring programme post works on Flood Relief
Scheme

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1 Introduction

1.1 Background

In November 2009, severe flooding from the Dunkellin River and Aggard Stream caused widespread disruption and property damage in the Craughwell and Kilcolgan areas of County Galway. To address the issue, the Office of Public Works (OPW) launched a detailed investigation into the flood's origins and impacts, to identify a preferred flood relief scheme (FRS) that would reduce the frequency and/or impact of similar future flooding. In 2011, Galway County Council commissioned an assessment of the likely environmental impacts of the proposed scheme. The final agreed scheme included a combination of flood relief works such as widening and deepening the river, upgrading and replacing culverts, improving and replacing bridges, and maintaining river channels. The scheme was designed to provide optimum flood relief with minimum environmental impact, while also meeting cost-benefit requirements. The planning application for the scheme (07.JA0035) submitted by Galway County Council, was granted with seven associated conditions. Of these, Condition No. 4 states:

'For a period of five years following completion of all works, the local authority shall undertake annual monitoring at Rahasane Turlough, to include:

- (a) field assessment of swallow holes and recording of natural collapse of conduits or infilling of swallow holes*
- (b) monitoring of water level at existing river gauges up and down gradient of Rahasane Turlough, and*
- (c) monitoring of vegetation and indicator species at Rahasane Turlough*

Reason: In the interest of the protection of the environment and to broaden scientific knowledge.'

Works on the FRS are complete and Galway County Council, wishing to fulfil its commitments under Condition 4 of the issuance of planning permission, have appointed APEM to undertake the required field surveys and assessments for a period of five years, starting from July 2021. In each year to date, APEM Group, Woodrow has undertaken the agreed monitoring and submitted an annual findings report. This is the final report to be issued, marking the end of the five-year monitoring period.

The main concern for the site relates to possible changes in the hydrological regime and in particular, evaluating whether implementation of the FRS might lead to any drying out/reduction in the extent and/or frequency of flooding. According to the Environmental Impact Assessment the alterations to the Dunkellin River and its bridges have been designed to have virtually no impact on the hydrological regime of Rahasane Turlough. Turlough water levels are predicted to change slightly, but these are not significant under flood conditions. Maximum flood levels are predicted to remain unchanged and predicted surface water profiles for various flow scenarios (e.g. 5th percentile, 10th percentile) show no perceptible changes between the pre- and post-works situations. However, the impact of a possible change in the hydrological regime of the turlough may be detected through the monitoring proposed by An Coimisiún Pleanála (ACP; previously An Bord Pleanála), as follows:

1. Reduction in number, or complete cessation, of changes to the physical structure of the karst below the turlough, e.g. reduced/zero new incidences of collapse or infilling of swallow holes;
2. Lower water levels and reduced flow volumes and velocity into / out of the turlough as compared to those recorded in the past;
3. Changes in composition of the vegetation, e.g. a shift away from wetland species to more dryland species, and;
4. Changes in the composition of freshwater macroinvertebrate fauna from one characteristic of a regularly flooded habitat to one of a more frequently dry habitat.

1.2 Rainfall patterns

Overall patterns in rainfall are an important consideration in evaluating any changes in the hydrology of a turlough as annual changes in precipitation will generate different responses in terms of timing, duration and frequency of turlough flooding (Waldren, 2015).

A review of rainfall data across the baseline years (2014–2015) and the monitoring years (2021–2025) indicates relatively high variability among years (Table 1-1; Figures 1-1 and 1-2). Nevertheless, patterns across summer months in the baseline years were within a similar range to the later (monitoring) years (Figure 1-1).

Table 1-1: Monthly Rainfall Totals (June–September) for Baseline (2014–2015) and Monitoring (2021–2025) Periods at Athenry Weather Station²

Month Year	June	July	August	September	Total Rainfall June – September
2014 (RPS)	38.6	92.4	104.9	10.4	246.3
2015 (RPS)	44.9	138.2	114.6	93.3	390.9
2021	29.8	58.5	84.8	91.1	264.2
2022	79.4	66.0	79.6	114.2	339.2
2023	93.8	224.1	129.1	148.2	595.2
2024	58.9	71.5	159.0	46.6	336.0
2025	165.0	148.3	147.0	143.7	604.0

Monthly summer rainfall in the baseline period follows a similar overall pattern in both years increasing from June to July, and decreasing from August to September, although 2015 had almost 60% higher rainfall than the previous year (Figures 1-1 and 1-2).

The monitoring years (2021–2025) continue to show notable fluctuations, with some years marked by particularly high mid-summer rainfall, especially when compared to the baseline years. For instance, 2023 includes an especially wet July along with elevated August and September. 2025 stands out even more, recording the highest June total in the dataset and consistently high values throughout the rest of the summer. Other monitoring years, such as 2021, 2022 and 2024, had drier summer conditions overall (Figure 1-2), although 2024 included a wet August.

No clear trend emerges, with summer peaks occurring in different months. Nevertheless, several of the monitoring years (2023 and 2025) exhibit more pronounced mid-summer rainfall peaks than those observed during the baseline period. When considering turlough hydrology following the FRS, these observations highlight the need to consider climatic variation as changes in seasonal inundation patterns may be related to these wetter summer conditions.

² [Met Eireann Historical Data](#)

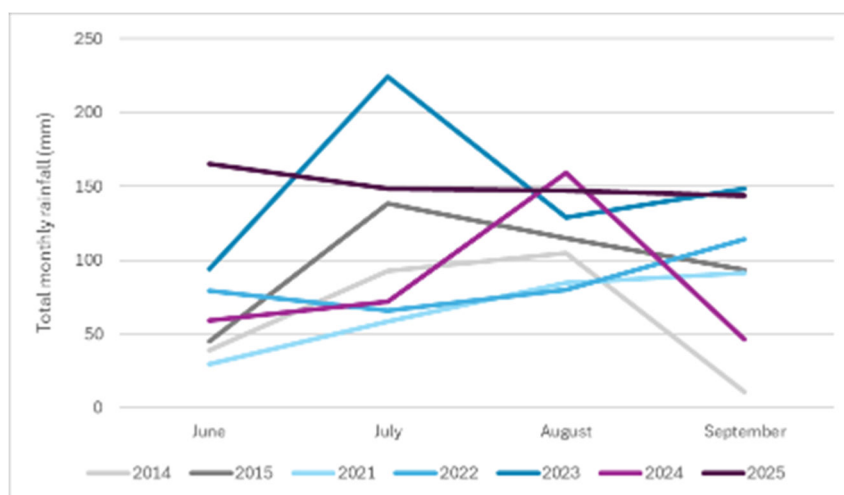


Figure 1-1: Monthly rainfall from June–September (mm) for baseline (2014–2015) and monitoring (2021–2025) periods at Athenry weather station³

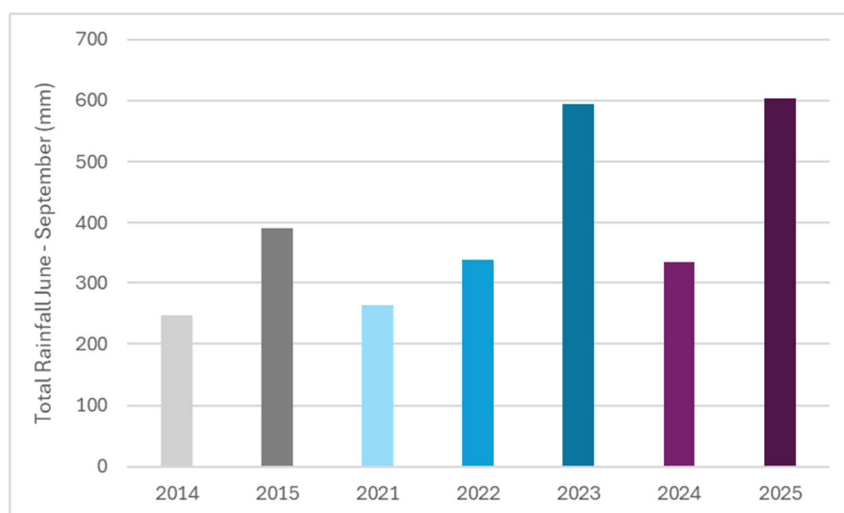


Figure 1-2: Total rainfall from June–September (mm) for baseline (2014–2015) and monitoring (2021–2025) periods at Athenry weather station²

-1:

³ [Met Eireann Historical Data](#)

1.3 Aim of this Report

After five years of annual monitoring of the Rahasane Turlough, the aim of this final report is to compare the trends observed over the years of monitoring from 2021 – 2025 inclusive, post-construction of the Flood Relief Scheme (FRS), to those observed in baseline surveys conducted pre-construction of the FRS and any other relevant historic information or appropriate scientific literature available to meet the requirements of Condition No. 4 under which An Bord Pleanála (now an Coimisiún Pleanála) granted the application (07.JA0035) and to address the primary concerns relating to the site's hydrological, hydrogeological, and ecological characteristic, i.e. any potential changes to the turlough's annual hydrological regime, particularly whether the implementation of the FRS could result in drying out or a reduction in the extent and/or frequency of flooding.

1.4 Report Structure

The report is structured as follows, to meet the requirements of Condition No. 4 under which ACP granted the application (07.JA0035):

- Chapter 2 (Hydrogeology and Hydrology Surveys) will report the survey results of the past 5 years of monitoring (including the latest results from 2025) in particular focussing on Condition 4 part (a) '*field assessment of swallow holes and recording of natural collapse of conduits or infilling of swallow holes*' and on Condition 4 part (b) '*monitoring of water level at existing river gauges up-gradient and down gradient of Rahasane Turlough*'. It will compare hydrological and hydrogeological conditions over the past five years, exploring whether there is evidence that these parameters and the overall hydrological regime of the turlough have changed post-construction of the scheme.
- Chapter 3 (Vegetation Surveys) will report survey results from the past five years of vegetation monitoring, including the latest results from 2025, with particular focus on the first part of Condition 4 part (c) '*monitoring of vegetation... at Rahasane Turlough*'. It will compare the results of the annual surveys conducted over the past five years with pre-construction baseline observations (including historical data), examining if there is evidence that the vegetation communities within the turlough have changed post-construction of the scheme.
- Chapter 4 (Macroinvertebrate Surveys) will report the survey results of the past 5 years of macroinvertebrate and macrophyte monitoring, with particular focus on the second part of Condition 4 part (c) '*monitoring of ... indicator species at Rahasane Turlough*'. It will compare the results of the annual surveys conducted over the past five years with pre-construction baseline observations (including historical data), examining whether there is evidence that the aquatic ecological communities within the turlough have changed post-construction of the scheme.
- Chapter 5 (Conclusions) will summarise the overall findings of the monitoring programme, concluding, based on evidence gathered through annual surveys, whether the site's hydrological, hydrogeological, and ecological characteristic has changed in response to the FRS.

2 Hydrogeology and Hydrology Surveys

2.1 Objective and outline of methods

The ecosystem associated with the Rahasane Turlough SAC is highly dependent on the hydrological flow regime at the site. The hydrological flow regime is, in turn, defined by the karst system that underlies the turlough catchment. The surface expression of the karst system is manifested by karst features such as caves, swallow holes, estavelles (ground features that can act as a sink or supply of water depending on surrounding hydrological and hydrogeological conditions) and springs. The key challenge is differentiating natural changes in hydrological behaviour from those which may be attributed to the flood scheme. To meet this challenge, we have undertaken the following:

- Review of previous datasets and reports;
- Five annual drone surveys, of which the 2025 survey was the final one;
- Annual visit and brief assessment of the three OPW hydrometric stations associated with the Rahasane Turlough;
- Collation and assessment of relevant hydrometric station data over the study period; and
- An annual site walkover of the turlough to ground-truth and observe karst features for monitoring purposes.

2.2 Review of previous datasets and reports

The following sources of site-specific data were reviewed at start of the project and re-visited as required throughout the survey period:

- OPW – 2018 Flood Risk Management Plan – Galway Bay South East;
- OPW – 2019 Strategic Environmental Assessment Statement - Galway Bay South East;
- OPW – 2010 Preliminary Flood Risk assessments – Groundwater Flooding;
- RPS - 2014 Environmental Impact Statement (Dunkellin River and Aggard Stream Flood Relief Scheme);
- RPS – 2014 Natura Impact Statement (Dunkellin River and Aggard Stream Flood Relief Scheme);
- RPS – 2016 Preconstruction Assessment Geology and Hydrogeology; and
- OPW – Water level and flow data at gauging stations deemed relevant to the FRS, notably on the Dunkellin River near the Rahasane SAC.

The following additional sources of publicly available data and information were checked and used as appropriate:

- Geological Survey Ireland (GSI) web-based groundwater data viewer, specifically the GSI karst database;
- Ordnance Survey Ireland (Geohive) – Historic maps and aerial photography;
- Environmental Protection Agency (EPA web-based data viewer “EPA map viewer”); and
- National Parks and Wildlife Service (NPWS) web-based data viewer (Special Areas of Conservation; Special Protection Areas).

2.3 Annual Drone Survey

The fifth of five annual aerial photography surveys of the Rahasane Turlough was conducted by MKO in August 2025 using a DJI Matrice 30T drone to assist with the ground-truthing and monitoring of karst features.

The aerial photography was processed using Agisoft Metashape and can be viewed on ArcGIS. The geometrical resolution on the ground is approximately 30 mm/px with the drone flying at 80 m height, 6 m/s, 80% overlap and 70% sidelap. The drone was mounted with a dedicated RTK hardware module, increasing its positioning accuracy up to 10 mm on the horizontal plane and 20 mm on the vertical plane.

The 2024 survey was completed as outlined above. The 2023 aerial imagery was provided by Bluesky specified to a resolution of 250 mm. The imagery captured in 2021 – 2022 was conducted using a DJI Mavic 2 Pro drone flown at a height of 125 m and processed using the software programme DroneDeploy.

Access to view and compare the processed and collated imagery for 2021 - 2025 has been provided to Galway County Council.

2.4 OPW Hydrometric Stations

OPW Hydrometric Stations (gauging stations) are measurement stations installed on rivers and lakes to record water levels, temperature and/or flow, mainly for flood risk management purposes. In the context of the FRS and the Rahasane Turlough SAC, three existing hydrometric stations on the Dunkellin River were visited in August 2025:

- Craughwell 29007
- Aggard Bridge 29010
- Rahasane Turlough 29002

These stations measure water levels upstream (29007, 29010) and downstream (29002) of Rahasane Turlough. Their locations are shown on Drawing 1 in Appendix A.

2.4.1 Craughwell 29007

Craughwell 29007 (Figure 2-1) is a relatively new hydrometric station on the Dunkellin River. It is approximately 230 m downstream of former monitoring station 29007, which was replaced with the new station following the construction of the FRS through Craughwell village. The new station 29007 is located upstream of a bridge and is positioned to measure the river levels where the natural river course and the FRS are combined. It records the water level and temperature at 15-minute intervals using an OTT PLS sensor. The data are stored in a data logger and automatically loaded to a server via solar-powered telemetry.

The riverbanks are built up with rocks for stability purposes, to a level of approximately 2.7 m above the stream bed. There is a concrete structure which slopes 45° towards the stream at the base of the nearby bridge. The riverbed at the hydrometric station appears relatively clean, i.e. free of vegetation or other obstacles. Conditions have not changed over the 5-year monitoring period.



Figure 2-1: OPW Hydrometric Station Craughwell 29007 (facing downstream)

2.4.2 Aggard Bridge 29010

Aggard Bridge 29010 (Figure 2-2; Figure 2-3) records the water level and temperature on a tributary of the Dunkellin River at 15-minute intervals. Data are recorded using an OTT sensor and stored in an in-situ data logger (Figure 2-3). The data are automatically transmitted to a server via solar-powered telemetry. The stream banks are heavily vegetated and the profile of the tributary changes over short distances. Downstream, the flow is channelled under a bridge. Some vegetation is present growing on the riverbed at Aggard Bridge (Figure 2-4). Conditions have not changed over the 5-year monitoring period.



Figure 2-2: Aggard Bridge 29010 Hydrometric Station (facing downstream)



Figure 2-3: Aggard Bridge 29010 Data Logger

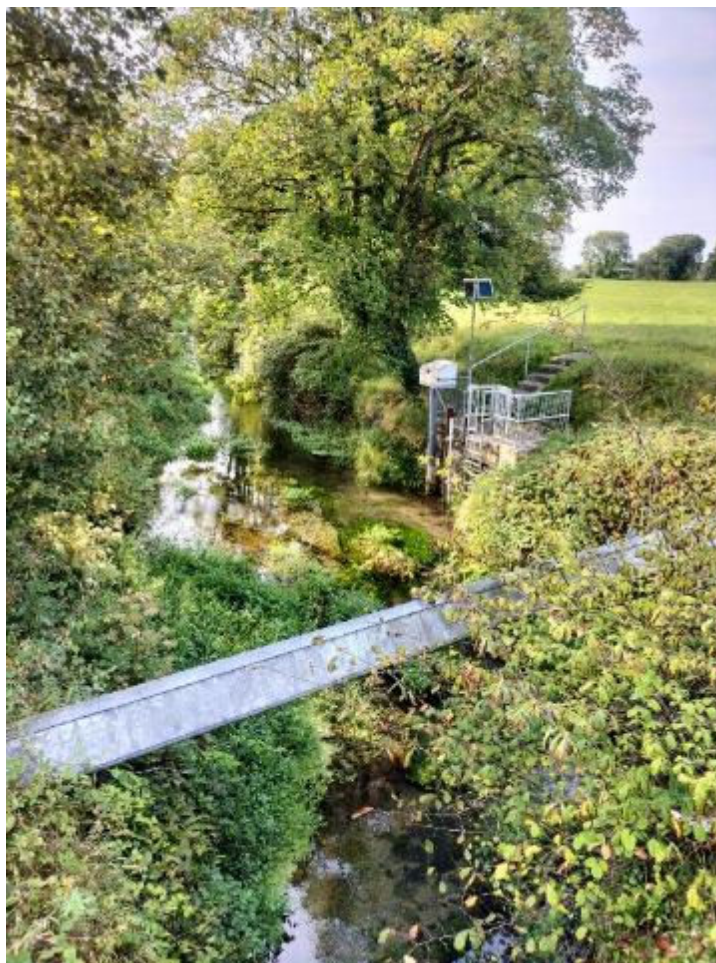


Figure 2-4: Vegetation at Aggard Bridge (facing upstream)

2.4.3 Rahasane Turlough 29002

Rahasane Turlough 29002 (Figure 2-5) records the water level and temperature of the Dunkellin River approximately 80 m downstream of the Rahasane Turlough SAC. Data are recorded at 15-minute intervals using an OTT sensor and stored in a data logger. The data are automatically loaded to a server via solar-powered telemetry. The riverbanks at and upstream of the monitoring station are heavily vegetated. Conditions have not changed over the 5-year monitoring period.



Figure 2-5: Rahasane Turlough 29002 Hydrometric Station

2.5 Results

2.5.1 Hydrometric Station Data

Water level data for each of the hydrometric stations are graphed below for the period from the inception of this project (third quarter (Q3) of 2021, i.e. July, August, September) through the third quarter (Q3) of 2025. The data were obtained by the OPW Hydro-Data website (www.waterlevel.ie). Daily rainfall data from the Craughwell weather station (www.met.ie) were added to the graphs for illustration purposes (note: this data runs through end of August 2025 only).

Water level data for Q3 2021 through Q3 2025 for Craughwell 29007 are presented in Figure 2-6. During this period, water levels ranged from 17.11 m OD to 19.17 m OD (mean = 17.60 m OD). The highest recorded water level was on 21 October 2023. In 2024, water levels were at their lowest from July to end August ranging from 17.17 to 17.22 m OD. Water levels during summer 2025 were flashier comparable to the summer of 2024 with water levels increasing during and following rainfall events.

Water level data for Q3 2021 through Q3 2025 from Aggard are presented in Figure 2-7. During this period, water levels ranged from 21.04 m OD to 21.92 m OD (mean = 21.36 m OD). The highest recorded water level was on 17 September 2025.

Water level data for Q3 2021 through Q3 2025 from Rahasane Turlough 29002 are presented in Figure 2-8. Water levels over this period ranged from 13.6 m OD to 16.8 m OD (mean = 14.5 m OD). Water

levels at this location are very similar to 29010 and 29007. As with the other streams, the summer of 2025 experienced a gradual, but flashy decrease in water levels. There was less rainfall in winter 2024/2025 than previous years. As with Craughwell 29007 and Aggard 29010, the high rainfall events in winter, spring and summer are all mirrored by increased stream water levels.

The correlation between incoming and outgoing flows is not linear. It can be influenced by the karst system dynamics of the Rahasane Turlough.

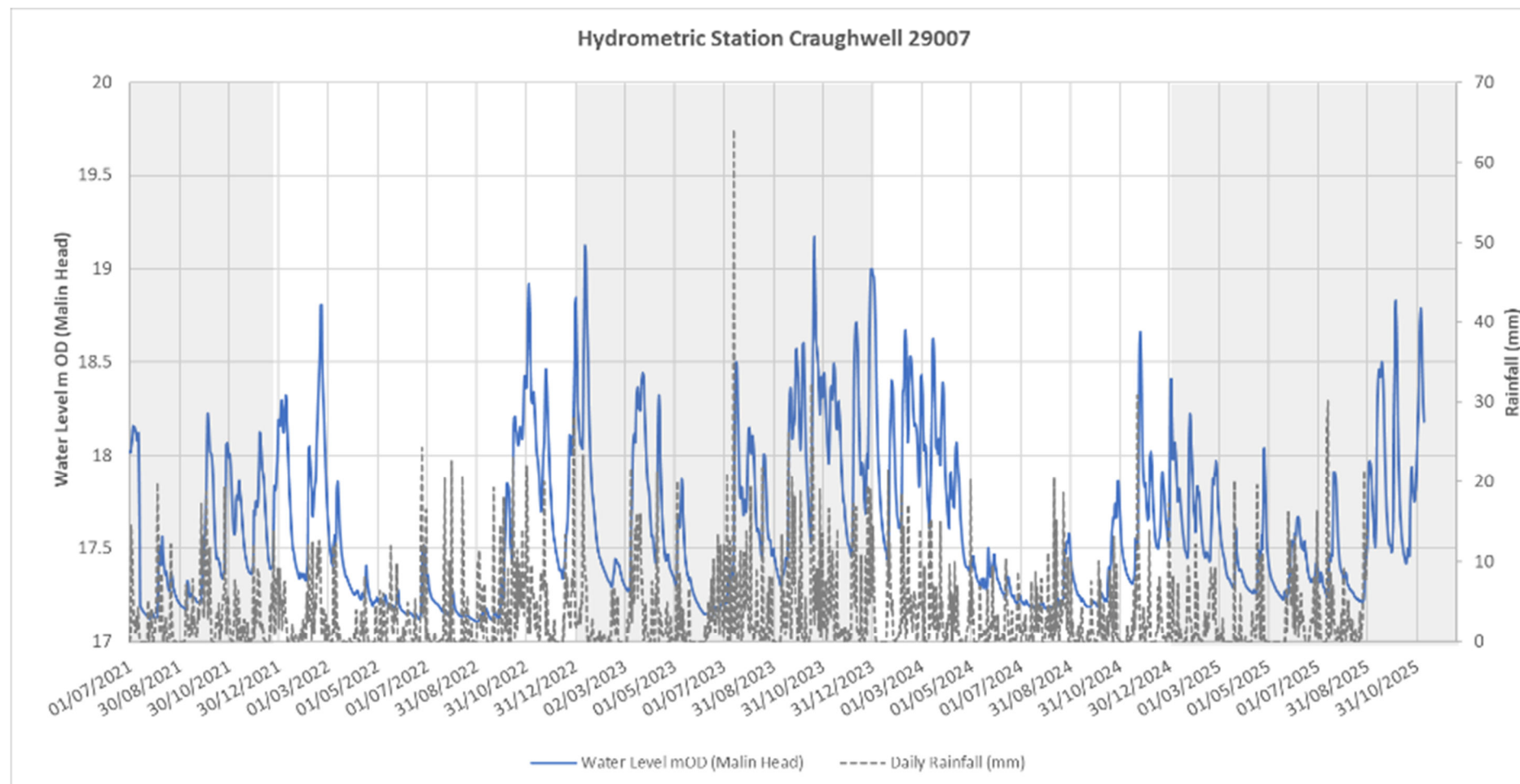


Figure 2-6: Water levels and rainfall at Craughwell Hydrometric Station from 2021 to 2025.

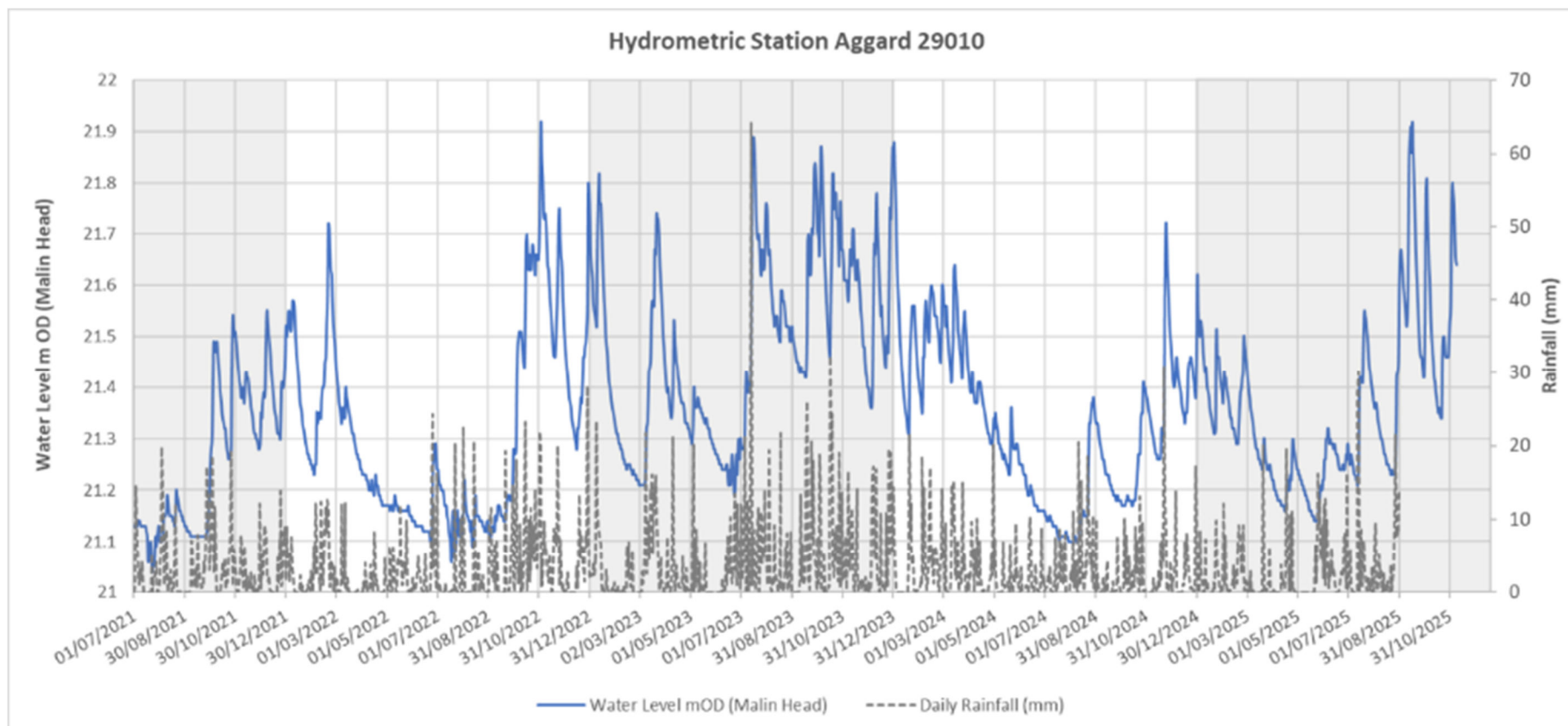


Figure 2-7: Water levels and rainfall at Aggard Hydrometric Station from 2021 to 2025.

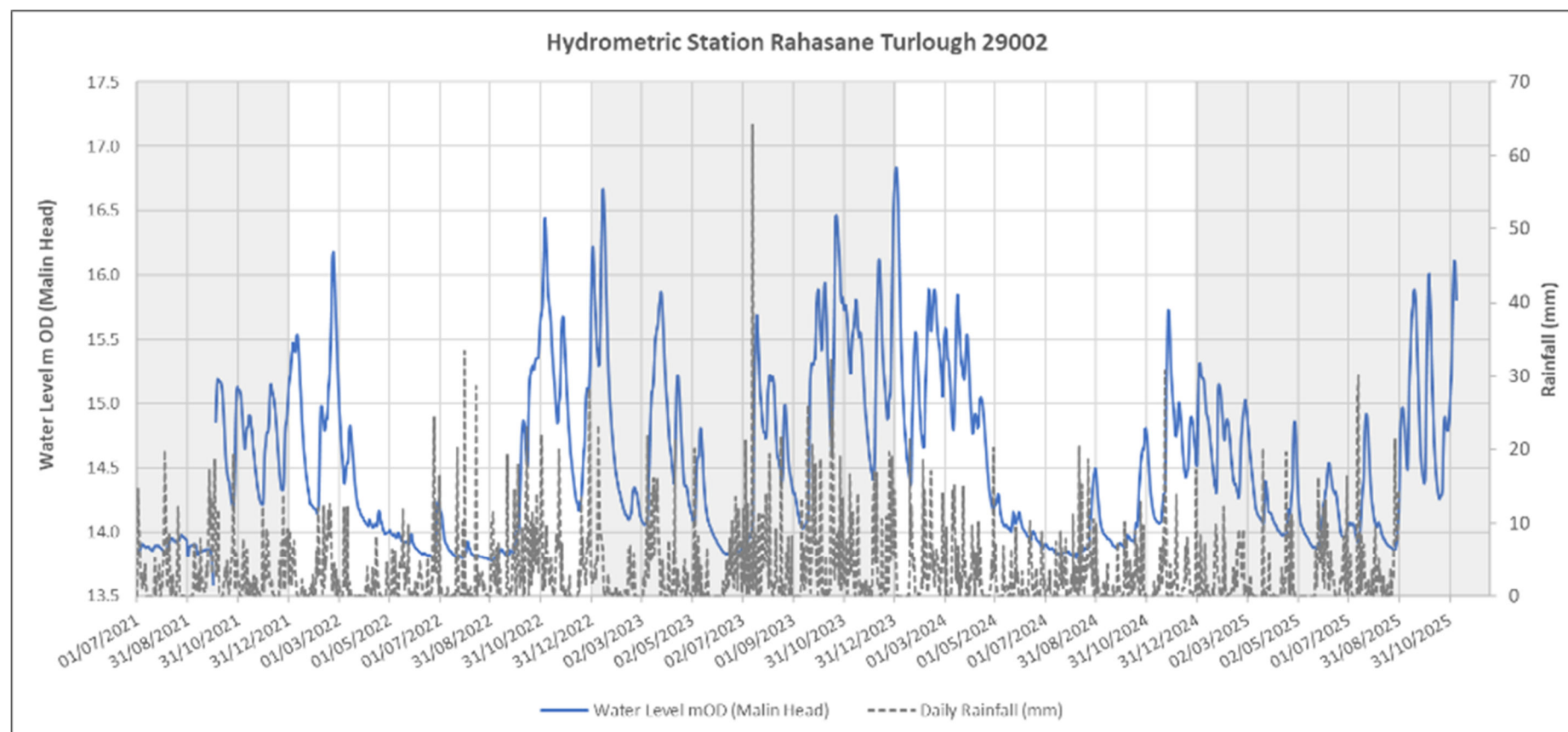


Figure 2-8: Water levels and rainfall at Rahasane Turlough Hydrometric Station from 2021 to 2025.

2.5.2 Drone Survey

The fifth of five annual aerial photography surveys of the Rahasane Turlough was conducted by MKO on the 7th and 8th of August 2025 using a DJI Matrice 30T drone. Water levels were low during the drone survey; approximately 95 % of an estimated total turlough area of 3.27 km² (NPWS) was above water.

Access to view and compare the processed and collated imagery for 2021 - 2025 has been provided to Galway County Council.

2.5.3 Walkover survey – Rahasane Turlough

The fifth walkover survey took place on 21st August 2025. The purpose of the walkover survey was to:

- a) monitor the features recorded during the 2021 - 2024 walkover; and
- b) record features exposed by the low turlough water level, where present.

During the 2025 walkover, the water levels in the turlough were very low. Water levels in summer 2025 were slightly lower than summer 2024 and 2023. Many of the features were accessible on the day of the walkover.

Known karst features in the Rahasane Turlough SAC are shown on Drawing 1 (Appendix A) and listed in Table 2-1. These incorporate those features in the GSI database, those mapped by RPS from Lidar data during the FRS project and those that were ground-truthed or identified during the site walkover survey from 2021 - 2024.

Specific other features of interest noted on the site walkover survey are summarised in Table 2-1 and include monitoring wells. The team checked with GSI and other researchers of turlough hydrology, but the purpose or circumstances around the presence of monitoring wells are not known.

A selection of images of features during both this year and 2021 - 2024 is provided in Plates 1 through 7, for comparison.

2.6 Discussion

Most of the karst features identified during the 2021 through 2024 surveys could be accessed and monitored in 2025. OPW hydrometric data indicate water levels fluctuated but consistently fell over winter 2024/2025 through to August 2025. Water levels did not reach the high levels of 2023 and remained the lowest since monitoring began over the 2024/2025 winter period.

There is no obvious change in karst features during the last five years of monitoring between 2021 and 2025. Water levels were low in 2021, 2022 and 2025 walkover surveys and many features could be monitored in this final survey year. Water levels were higher in 2023 and 2024 (related to higher rainfall preceding the surveys) and a lot of features could not be visited in those years. Consistent with all previous reports (Rahasane Turlough Monitoring 2021 – 2024) there is no change in karst features. Aerial imagery shows no apparent change in karst features at Rahasane Turlough over the previous 5 years. In conclusion, no change in the hydrogeological regime of the Rahasane Turlough is apparent since implementation of the Dunkellin River and Aggard Stream Flood Relief Scheme.

Table 2-1: Summary of hydrogeological and hydrological features at the Rahasane Turlough

ID*	X (ITM)	Y (ITM)	Feature	Comment	Apparent Change between 2021 & 2025
A1	546108	718854	Enclosed depression	Monitor for changes.	No change
A2	546310	718914	Dunkellin River	Hydrological reference feature – observation point within turlough.	Some debris at base of bridge
A3	546327	718940	10+ small scale depressions	Possible near surface expression of epikarst. Monitor for changes.	No change
A4	546325	718991	Enclosed depression	Monitor for changes.	No change
A5	546570	719115	Area receiving inflow from river	Possible nearby swallow hole.	No change
A6	546653	719086	Wetland vegetation	Monitor for changes – ecologist	No change
A7	546681	719110	50+ small depressions of Approx. 200 mm diameter	Possible near surface expression of epikarst. Monitor for changes.	No change
A8	546689	719158	Enclosed depression	Possible location for groundwater recharge/discharge (estavelle). Monitor for changes	No change
A9	546912	719483	Monitoring well	Condition unknown. Consider condition survey for possible monitoring.	No change – condition remains unknown
A10	547683	718724	Existing well	Condition unknown. Consider condition survey for possible monitoring.	No change - condition remains unknown
A11	547408	718725	Enclosed depression	Possible location for groundwater recharge/discharge (estavelle). Monitor for changes.	No change
A12	547411	718730	Enclosed depression	Possible location for groundwater recharge/discharge (estavelle). Monitor for changes.	No change
B1	546551	718960	Small scale depression	Monitor for changes.	No change
B2	546629	719112	Estavelle (?) Low water levels (<200 mm)	Possible location for groundwater recharge/discharge. Monitor for changes.	No change

ID*	X (ITM)	Y (ITM)	Feature	Comment	Apparent Change between 2021 & 2025
B3	546839	719313	Estavelle/spring	Feeds stream that flows SW to main channel. Monitor for changes.	No change
B4	547006	719548	Turlough water	-	No change
B5	547308	719874	Estavelle	Location of groundwater recharge/discharge. Monitor for changes.	No change
B6	547310	719876	Estavelle	Location of groundwater recharge/discharge. Monitor for changes.	No change
B7	547320	719912	Localised depression	Small scale depression. Monitor for changes.	No change
B8	547857	720058	Pond	Appears to drain to main channel. Source unknown. Monitor for changes.	No change
B9	547998	720015	Old Dunkellin channel	Monitor for changes	No change
B10	548042	720136	Estavelle	Location of groundwater recharge/discharge. Monitor for changes	No change
B11	548090	720139	GW in depression	Small scale depression. Monitor for changes.	No change
C1	547145	718622	Estavelle	High water levels in estavelle	No change
C2	547311	718809	Estavelle	Appears quite deep. Possibly a sinkhole	No change
C3	545967	718122	Enclosed Depression	Small scale depressions c. 0.5 m wide	No change
C4	545995	718203	Enclosed Depression	Large depression	No change
C5	545974	718132	Enclosed Depression	Depression c. 50 m wide	No change
C6	545900	717983	Monitoring well	Monitor for changes	No change
D1	546264	718862	Series of potentially 5 swallow holes	Swallow hole draining the Dunkellin River and several more to the south	No change
D2	546127	718130	Large depression	Large depression c. 200 m wide	No change
D3	546245	718365	Large channel like depression	Channel shaped depression which connects to D3 above	No change
GSI 1	547409	718761	Spring	Monitor for estimated flow	No change
GSI 2	547732	718806	Enclosed depression	Monitor for changes	No change
GSI 3	546483	718930	Swallow hole	Monitor for changes	No change
GSI 4	548512	719832	Enclosed depression	Monitor for changes	No change
GSI 5	548647	719790	Enclosed depression	Monitor for changes	No change
GSI 6	549994	719655	Swallow hole	Monitor for changes	No change

ID*	X (ITM)	Y (ITM)	Feature	Comment	Apparent Change between 2021 & 2025
GSI 7	550433	719748	Swallow hole	Monitor for changes	No change
RPS 1	550577	719824	Enclosed depression	Monitor for changes	No change
RPS 2	547982	719853	Enclosed depression	Monitor for changes	No change
RPS 3	548582	719523	Enclosed depression	Monitor for changes	No change
RPS 4	548744	719523	Enclosed depression	Monitor for changes	No change
RPS 5	547832	719589	Enclosed depression	Monitor for changes	No change
RPS 6	547473	719282	10+ small scale depressions	Possible near surface expression of epikarst. Monitor for changes.	No change
RPS 7	547372	718848	Enclosed depression	Monitor for changes	No change
RPS 8	547041	718867	Enclosed depression	Monitor for changes	No change
RPS 9	546943	718755	Enclosed depression	Monitor for changes	No change
RPS 10	546994	718861	Enclosed depression	Monitor for changes	No change
RPS 11	546920	719065	Enclosed depression	Monitor for changes	No change
RPS 12	546509	718456	Enclosed depression	Monitor for changes	No change
RPS 13	546205	718203	Enclosed depression	Monitor for changes	No change
RPS 14	545843	717986	Enclosed depression	Monitor for changes	No change
RPS 15	546277	718983	Enclosed depression	Monitor for changes	No change
RPS 16	546459	719099	Enclosed depression	Monitor for changes	No change

*ID with prefix A: features identified by CDM Smith in 2021; ID with prefix B: features identified by CDM Smith in 2022; ID with prefix C: features identified by MKO in 2024; ID with prefix D: features identified by MKO in 2025; ID GSI 1-7: GSI features; ID RPS 1-16: RPS features

3 Vegetation Surveys

3.1 Review of Previous Datasets and Reports

Vegetation monitoring at Rahasane Turlough has been carried out over the five-year period 2021-2025 to identify potential patterns of change in vegetation communities following drainage interventions on the Dunkellin River (see Section 1.1). Potential impacts include extended dry periods, reduced inundation extent or less frequent flooding events. Such hydrological changes would likely be reflected in shifts in the composition and structure of the turlough's vegetation communities.

The vegetation communities of turloughs are of high ecological interest and conservation importance for two reasons in particular:

- Turloughs are extremely rare in a European and global context, with almost all examples found in Ireland.
- The unusual and dynamic seasonal water regime facilitates a distinct range of plant species, some of which are not widely found outside of these habitats.

This ecological rarity and importance are emphasised by the fact that turloughs are listed as priority habitats in the EU Habitats Directive (EU habitat code 3180). The vegetation of turloughs reflects their transitional nature, with a very dynamic water regime. The composition of the vegetation tends to change in accordance with the flooding gradient and the amount of time per year that each particular area is inundated.

A comprehensive study of turlough vegetation in Ireland was undertaken on behalf of the National Parks & Wildlife Service (NPWS) by Waldren (2015). In addition, NPWS commissioned a Conservation Objectives supporting document (O'Connor, 2017) to cover 45 Special Areas of Conservation (SACs) selected for the Annex I priority habitat Turloughs (3180), for which individual Conservation Objectives Supporting documents had not been prepared. These documents were reviewed to inform the methodological approach to surveying.

The vegetation of Rahasane Turlough was surveyed in detail by Goodwillie (1992) as part of a study of 61 Irish Turloughs commissioned by NPWS. This survey focused on distinctive plant communities and specific indicator species, to ascertain the flora present and to examine any habitat variation, including variation between Rahasane and other turloughs.

3.1.1 Description of Rahasane Turlough Vegetation Communities (Goodwillie, 1992)

'Vegetation: *The vegetation of Rahasane divides into the dry and the wet rather more neatly than most others. In places with outcropping limestone the edge vegetation is predominantly 2C⁴ (Limestone grassland community), though this breaks down to 5A (Dry annuals) on the north shore where trampling is intense and some animals are over-wintered. In a few places on the southern edge, leaching has gone far enough to allow 3B (Sedge heath community) to grow as a fringe below the more calcicole community. Elsewhere there are stretches also of 2A (Lolium grassland) and 2B (Poor grassland) on the flooded edges of agricultural fields. 5B (Potentilla reptans) occurs in very large expanses at both ends of the turlough. It covers practically all of the southern basin on the firm, sheep-grazed floor and extends also around the nearby edges of the main basin.*

⁴ Full list of Goodwillie community types found in Table B-1, Appendix B

At the eastern end it is found on the drier ground where the river follows its own channel. In the central southern section as well as in the southern turlough *Potentilla reptans* disappears from the vegetation, perhaps because of slightly poorer drainage, leaving 6A (Dry *Carex nigra*) which locally contains *Viola persicifolia*⁵. The ground here is again very firm but the presence of low-growing *Eleocharis palustris* suggests that there is water not far below. This plant is most frequent in the shallow, winding channels that take the rising or retreating floods. Occasionally these lead into 8A (*Polygonum amphibium*), *Polygonum amphibium* benefitting from the accumulation of nutrients brought to such pools.

The wet communities are all associated with the river channels, both natural and artificial. Water escapes northwards just as the turlough broadens out below the site of Shanbally Castle and standing water persists all summer as a track south-westwards down to the swallow holes. The fully aquatic community here (11B – Peaty Pond) includes *Ranunculus circinatus* and *Potamogeton pectinatus* while the pool to the north-west has *P. pusillus* and *Eleocharis acicularis*. 9A (Temporary Pond) adjoins on the north side of the river and contains a little *Rorippa sylvestris* close to the shoreline in rather prostrate form. At each end of the main water track there are shallows which dry out occasionally and are covered with 10A (*Oenanthe aquatica*) with a little *Lemna gibba*, perhaps drifted in from the south.

Between the two rivers, natural and artificial, is a broad island of splashy grass - *Polygonum amphibium* communities of both 7A (*Oenanthe aquatica* community) and 8A which are consistently grazed by cattle. A few individual ponds are sunk in this and there is a muddy area also, with *Rorippa islandica*. 7A is repeated along the north shore east of Shanbally Castle while there are also some narrow fields with *Iris* (3A – Tall Herb).

The main channel of the river has bands of 10B along each side, sometimes with a deeper central section of pondweeds (12 – Open Water). *Berula erecta*, *Apium nodiflorum* and *Polygonum amphibium* occur marginally and there is a little *Oenanthe fluviatilis*. *Rorippa islandica* grows in places along the edge and Lockhart (unpub.) records *Myriophyllum verticillatum* also.

Although there are areas of scrub, particularly on the southern and north-western shores, the actual area of flooded woodland is too small to be mapped. It is of 3W (*Rhamnus* Wood) type with some *Rhamnus cathartica* and in Carrigeen West it leads into drier ash/hazel wood. Many of the trees have abundant epiphytes such as *Leskea polycarpa*, *Amblystegium riparium* and *Isopterygium elegans* as well as *Isoetecium myosuroides* and *Thuidium tamariscinum*.

Land Use: The turlough is closely grazed by cattle, sheep and horses: indeed the shortness of most of the vegetation is one of its chief features. Sheep are largely confined to the southern basin and the northern shore but the other animal's range everywhere. The artificial river channel is crossed by cattle in certain places where it is about 80cm deep. The southern turlough carried rather many cattle in 1990 which had turned the remaining water into muddy pools with scattered vegetation (Goodwillie 1992).'

3.1.2 Sharkey (2012) Turlough Vegetation Community Analysis

A further study was undertaken by Sharkey (2012), documenting the vegetation communities of 22 turloughs within Counties Galway, Clare, Roscommon and Mayo. A comparison table between both classification systems is shown in Appendix B. While the Sharkey study did not include Rahasane Turlough, the categorisation of turlough vegetation communities was updated in this study and this classification was specified for use in the surveys carried out at Rahasane from 2021 to 2025.

⁵ Now known as *Viola stagnina*

3.1.3 Pre-construction Surveys at Rahasane Turlough by RPS

Vegetation communities in Rahasane Turlough were surveyed by RPS environmental consultants during 2014-2015 in order to inform the planning submission for the Dunkellin River and Aggard Stream Flood Relief Scheme (RPS, 2016a).

This study revisited Goodwillie's transects and examined 12 transects and 249 relevés in detail. The results of the surveys by RPS were reviewed and used to inform the site selection process for the current study.

3.2 Methods

3.2.1 Survey Methods

Fieldwork methodology was adapted from Waldren (2015) in accordance with the scheduled and costed time available. This includes mapping of vegetation zones during the dry season (mid-summer to early autumn) using transects and vegetation monitoring in fixed position relevés. Plant identification followed the keys in *New Flora of the British Isles* (Stace, 2019).

The focus on vegetation units takes cognisance of the units specified by Goodwillie (1992) and Sharkey (2012), with the latter classification being used to produce the vegetation community maps. The vegetation monitoring places particular emphasis on indicator plant species (both positive and negative), as listed by O'Connor (2017) and Waldren (2015), and considers other indicative features, such as the presence and extent of algal mats and algal paper.

To select vegetation study areas for the five-year monitoring project, the transects and relevés in the RPS (2016a) survey were reviewed. A subset of 15 of these relevés along three transects were then selected for inclusion in this study. The transects and relevé locations are shown in Appendix C.

Fieldwork was undertaken by Dr Philip Doddy and Bridget Keehan in August 2021 and July 2022; by Philip Doddy, Adrian Walsh and Ana Lancastre in July 2024; and by Ana Lancastre, Adrian Walsh and Brittany Arendse in September 2025. No surveys were completed in 2023 as the turlough was flooded during the summer. All field surveyors are experienced ecologists with specialist skills in botanical field survey and habitat classification. Maps of the transect locations can be seen in Appendix C, Figures C-1 to C-4.

Transect and Relevés Selection

Transects and relevés were selected to provide a geographic spread across the turlough and to focus on areas previously identified as botanically diverse and important. As the transects and associated relevés were chosen based on the RPS (2016a) survey they enable a direct comparison with the baseline and with Goodwillie's 1992 survey of the Site, to assess any changes in vegetation composition, such as a shift from wetland species toward more dryland species or changes in community distribution along transect.

Vegetation Community Classification

The vegetation communities along each transect were identified and mapped, using the updated vegetation community classification system of Sharkey (2012). This was done by examination and recording of vegetation along the selected transects, identifying the points of transition to different vegetation zones along each transect. The ESRI ArcGIS Survey123 app was used to record accurate locations along transects and to take geo-referenced photographs. The vegetation zones were then mapped using QGIS.

Each of the selected 1 x 1 m relevés was examined, where accessible. For each relevé this included an assessment of its physical characteristics, vegetation cover, vegetation type, plant species present and percentage cover of each species, as well as notes on management and any observed pressures or threats.

3.2.2 Vegetation Survey Limitations

High water levels frequently restricted access to the site during the survey period. When access was not possible, repeated attempts were made on different days and under varying conditions throughout the season. Despite these efforts, access remained limited in some years, resulting in little or no data being collected.

In August 2021, moderate rainfall (Table 1-1; Figures 1-1; 1-2) led to elevated turlough water levels, resulting in several relevés being inaccessible. Water levels during the 2022 field season were high to moderate during the summer (June-August), permitting access to sites that had been inaccessible the previous year; however again not all relevés were accessible.

The summer of 2023 saw exceptionally high rainfall, especially in July where monthly totals reached 224.1 mm (Table 1-1). This was significantly higher than in previous years and resulted in the turlough remaining at winter water levels throughout the summer months (May-August). This prevented all vegetation surveying for that year. Although surveys resumed in 2024, elevated water levels again restricted access, with four relevés remaining inaccessible. Similar limitations occurred in 2025 due to persistently high rainfall, which permitted access to only three relevé locations.

Despite intermittent flooding, survey teams were able to walk the transects and record the spatial arrangement of terrestrial, intermediate and aquatic vegetation zones in all years except 2023. Although individual relevés were inaccessible, the overall vegetation zonation was mapped reliably, allowing assessment of community boundaries and shifts between hydrological zones. Across all years four relevés (T4R16, T4R18, T6R2, and T6R6) were consistently inundated by high water levels.

In general, the high level of grazing at Rahasane Turlough made the classification of vegetation challenging in some areas, as the vegetation was grazed down almost to soil level. Grazing pressure is noted to be a historical impact on this site (Goodwillie, 1992, see Section 3.1.1) and remains a consistent influence on site conditions. Any changes in grazing intensity would be expected to alter vegetation characteristics, although no specific recent changes are known. While grazing reduced vegetation height and cover in places, it did not prevent the classification of vegetation communities across the site.

A summary of relevé accessibility from survey years 2021 to 2025 is given in Table 3-1, green boxes with ticks indicate accessible relevés, while red boxes with a diagonal line denote inaccessible locations.

Table 3-1: Relevés accessible in each monitoring year (2021 – 2025)

Transect Relevé Year	Transect 2					Transect 4					Transect 6				
	T2 R2	T2 R4	T2 R6	T2 R12	T2 R16	T4 R5	T4 R10	T4 R16	T4 R18	T4 R22	T6 R2	T6 R6	T6 R12	T6 R16	T6 R18
2021	✓	✓	✓	✓	✓	✓							✓	✓	✓
2022	✓	✓	✓	✓	✓	✓	✓			✓			✓	✓	✓
2023															
2024	✓	✓	✓	✓	✓	✓	✓			✓			✓	✓	✓

Transect	Transect 2					Transect 4					Transect 6				
Relevé Year	T2 R2	T2 R4	T2 R6	T2 R12	T2 R16	T4 R5	T4 R10	T4 R16	T4 R18	T4 R22	T6 R2	T6 R6	T6 R12	T6 R16	T6 R18
2025	✓				✓	✓									

3.3 Vegetation Survey Results 2025

This section presents the results of the vegetation surveys conducted at Rahasane Turlough in 2025. A summary table is included to give a synopsis of the species present and vegetation cover in each relevé (Table 3-2).

Vegetation maps produced from the transect surveys are shown in Appendix D. In addition, comparisons with the results from the previous 2021, 2022 and 2024 surveys are discussed in Section 3.4.

As in previous survey years, the classification system of Sharkey (2012) corresponded only very approximately with the vegetation communities as recorded at Rahasane. This is not remarkable given that the set of turloughs studied by Sharkey did not include Rahasane, and such habitats are naturally variable in character. Nonetheless, the data gathered for each relevé in the present study includes species and percentage cover and could therefore be used in conjunction with a more closely tailored classification systems in the future for comparison.

3.3.1 Relevés

Three relevés, T2R2, T2R16 and T4R5 were surveyed in 2025, all located along the western and central margins of Rahasane Turlough (Transects 2 and 4) (Appendix C), as these were the only sections accessible during the field season (Table 3-1).

The three completed relevés (Table 3-2) capture a representative segment of the terrestrial-to-intermediate drawdown gradient described for turlough vegetation. T2R2, positioned on a higher margin (Appendix C), aligns with Sharkey's 7(15) *Lolium–Trifolium–Agrostis* community, a grazed upper-basin sward characterised by abundant creeping bent (*Agrostis stolonifera*), perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*) and is known to occur around the upper fringes of turloughs where disturbance and grazing are common (Sharkey 2021).

In contrast, T2R16 and T4R5 correspond to Sharkey's 3(19) *Potentilla anserina–Potentilla reptans*⁶ community, an intermediate, amphibious vegetation type typically situated from the middle to lower part of the flooding gradient, but not restricted to the lowest, permanently flooded areas (Sharkey 2021). This community is herb-dominated, with creeping bent, creeping buttercup (*Ranunculus repens*), creeping cinquefoil (*Potentilla reptans*) and silverweed (*Argentina anserina*) as constant species, often forming low swards across seasonally wet drawdown zones. The presence of scattered wet-edge taxa such as amphibious bistort (*Persicaria amphibia*), water forget-me-not (*Myosotis scorpioides*) and water mint (*Mentha aquatica*) at T2R16 and T4R5 reflects seasonal inundation influence, not topographic low-point status, which in 2025 lay further downslope but remained fully flooded.

As described by Sharkey (2012), some species such as creeping bent, creeping buttercup and silverweed possess broad moisture tolerances and thus occur across much of the basin, whereas

⁶ *Potentilla anserina* is now known as *Argentina anserina*. The old name is used when referring to the community types, while the new name is referred to when discussing the species.

obligate aquatic species are confined to permanent or near-permanent water at the turlough base. Together, the 2025 relevés therefore represent upper-margin pasture vegetation (zone 7) and intermediate drawdown communities (zone 3) along the accessible edges of Rahasane Turlough under unusually high-water conditions.

Table 3-2: Summary of vegetation relevé results, Rahasane Turlough, September 2025

Communities and species are colour-coded by typical favoured habitat as follows: yellow - usually terrestrial, blue - usually aquatic, grey – intermediate between aquatic and terrestrial. Darker grey cells show a species was not recorded in that relevé.

Transect	Transect 2				Transect 4	
Relevé Code	T2R2		T2R16		T4R5	
Location (ITM)	X: 543295, Y: 719789		X: 546546, Y: 718774		X: 547393, Y: 720048	
Vegetation zone (Sharkey, 2012)	7 (15) <i>Lolium-Trifolium-Agrostis</i>		3 (19) <i>Potentilla anserina</i> – <i>Potentilla reptans</i>		3 (19) <i>Potentilla anserina</i> – <i>Potentilla reptans</i>	
Vegetation height max (cm)	20		20		25	
Water height (cm)	0		0		0	
% graminoids	75		70		80	
% forbs	60		40		65	
% shrubs	0		0		0	
% bryophytes	1		1		<1	
% bare ground	0		0		0	
% poaching	0		0		0	
Species	% cover	DOMIN scale	% cover	DOMIN scale	% cover	DOMIN scale
<i>Achillea millefolium</i>	1	2				
<i>Agrostis stolonifera</i>	50	7	70	8	50	7
<i>Argentina anserina</i>	20	5	35	7	55	8
<i>Bellis perennis</i>	<4	3				
<i>Cardamine pratensis</i>	1	1	4	3	1	2
<i>Cerastium fontanum</i>	1	1			<1	1
<i>Cirsium arvense</i>	2	1	1	1		
<i>Galium palustre</i>			<4	3		
<i>Hypochaeris radicata</i>			1	1		
Leavy liverwort			<1	1		
<i>Lolium perenne</i>	20	5			15	5
<i>Mentha aquatica</i>					1	2
Moss sp. (<i>Kindbergia</i> sp.)	1	1				
<i>Persicaria amphibia</i>					<1	1
<i>Myosotis scorpioides</i>	1	1	2	2	3	1
<i>Plantago lanceolata</i>	1	1				
<i>Potentilla reptans</i>			3	3	5	4
<i>Ranunculus repens</i>	<4	3	5	3	2	2
<i>Rumex acetosa</i>	<4	2				
<i>Rumex crispus</i>	1	2	1	1	2	3
<i>Scorzoneroideis autumnalis</i>			4	3		
<i>Stellaria media</i>			1	1		
<i>Taraxacum officinale</i>	<4	2	2	2		
<i>Trifolium repens</i>	23	5	1	1	1	2
<i>Urtica dioica</i>	1	1				

3.3.2 Transect 2 Results

The 2025 walkover survey of Transect 2 recorded a varied sequence of vegetation and scrub communities, with transitions between improved pasture, *Agrostis–Potentilla* swards, wetter turlough margins and dense scrub (Appendix D).

At the southern end of the transect (point T2R19), vegetation began within 1(10) *Lolium perenne–Trifolium repens* pasture, dominated by perennial ryegrass with occasional white clover, cuckooflower (*Cardamine pratensis*) and creeping thistle (*Cirsium arvense*). This community extended northwards until a gappy treeline underlain by a stone wall (T2R18B), where mature ash (*Fraxinus excelsior*) up to 15 m tall formed a canopy over a dense hedge of blackthorn (*Prunus spinosa*), bramble (*Rubus fruticosus* agg.) and hawthorn (*Crataegus monogyna*). Nettle (*Urtica dioica*) was frequent on the ground layer, with rare dog rose (*Rosa canina*) and spindle (*Euonymus europaeus*) in the hedge.

Beyond this, a short section of 3(3) *Agrostis stolonifera – Ranunculus repens* community with dominant creeping bent, curled dock (*Rumex crispus*) and silverweed, with frequent spear thistle (*Cirsium vulgare*), occasional marsh bedstraw (*Galium palustre*) and white clover and hairy pennywort (*Hydrocotyle vulgaris*), creeping buttercup and hairy sedge (*Carex hirta*). This was followed by scrub (T2R18) dominated by hawthorn and blackthorn (approximately 5 m tall) and underlain by frequent nettles and occasional meadowsweet (*Filipendula ulmaria*) and creeping thistle.

North of the scrub, the transect opened into a broader, more stable grassy zone corresponding to 3(4) *Agrostis stolonifera–Potentilla anserina–Festuca rubra* at T2R17. Here, silverweed, creeping bent and red fescue (*Festuca rubra*) were co-dominant, accompanied by frequent glaucous sedge (*Carex flacca*), autumn hawkbit (*Scorzoneroides autumnalis*) and yarrow (*Achillea millefolium*). Lady's bedstraw (*Galium verum*) and marsh bedstraw occurred occasionally, with common bird's-foot-trefoil (*Lotus corniculatus*), white clover, daisy (*Bellis perennis*) and scarce marsh violet (*Viola palustris*) also present.

Moving further north, scrub thinned and the transect entered an extended zone of 3(19) *Potentilla anserina–Potentilla reptans* vegetation (T2R16, T2R15 and adjacent points). This community was dominated by silverweed and creeping bent with frequent creeping cinquefoil, abundant creeping buttercup, scattered curled dock, and occasional autumn hawkbit, cuckooflower, marsh bedstraw and scarce meadowsweet. At one point the vegetation became too deeply flooded to traverse, though the community remained consistent with 3(19) where visible.

At the northern end of the transect (T2R2 and T2R1) the vegetation begins with edge scrub habitat patch dominated by nettle, bramble and hedge bindweed (*Calystegia sepium*), with scattered young willow (*Salix spp.*), dog rose, blackthorn and occasional thistles indicated disturbance. The underlying ground layer contained a *Lolium–Trifolium* sward. This leads into 7(15) *Lolium perenne – Trifolium repens – Agrostis stolonifera* community with dominant creeping bent and perennial rye, with common white clover and silverweed, and occasional daisy, creeping thistle. Heading south along the northern section the habitat transitions into 3(19) *Argentina anserina–Potentilla reptans* vegetation as seen in the southern transect. Dominant species were silverweed creeping bent and marsh bedstraw. Northwards the transect is inundated with water and too deep to traverse.

Overall, the 2025 walkover shows a complex mosaic of improved pasture, intermediate *Agrostis–Potentilla* swards, wetter 3(19) communities and repeated incursions of scrub in the drier boundary areas.

3.3.3 Transect 4 Results

Only the northern section of Transect 4 was accessible in 2025 due to flooding (Appendix D). The survey began at T4R5 in 1(10) *Lolium perenne–Trifolium repens* pasture, dominated by perennial

ryegrass, with occasional white clover, frequent creeping thistle and cuckooflower. Occasional Yorkshire fog (*Holcus lanatus*), creeping bent, creeping buttercup, daisy, dandelion (*Taraxacum officinale*), scarce sheep's sorrel (*Rumex acetosella*) and yarrow were also present. This improved pasture ended abruptly at a hedge-and-wall boundary dominated by hawthorn and blackthorn, with abundant nettle and bramble in the understorey.

Beyond the hedge, the pasture transitioned into 3(19) *Potentilla anserina*–*Potentilla reptans* community, where silverweed, creeping bent and broad-leaved dock (*Rumex obtusifolius*) were dominant, accompanied by frequent curled dock and autumn hawkbit. A short distance further north, this shifted subtly into a closely related 3(19) expressions of the same *Potentilla*-dominated community, with perennial ryegrass reappearing in small amounts and additional species including creeping cinquefoil, creeping buttercup, mouse-ear chickweed (*Cerastium fontanum*), and both curled and broad-leaved dock.

As the transect approached lower ground, the 3(19) community gave way at T4R6 to wetter conditions corresponding to 2(18) *Agrostis stolonifera*–*Glyceria fluitans*. Here, creeping bent was dominant along with frequent water forget-me-not, creeping cinquefoil and scattered silverweed, with occasional floating sweet-grass (*Glyceria fluitans*), curled dock and marsh bedstraw. Standing water reached depths of 20–30 cm. This wet community continued to T4R7, where flooding prevented further progress northwards. The flooded area supported 2(2) *Persicaria amphibia*–*Eleocharis palustris*.

Overall, the accessible section of Transect 4 in 2025 exhibited a clear hydrological gradient from improved pasture on slightly elevated ground, transitioning through (19) *Potentilla anserina*–*Potentilla reptans* community before giving way to wetter 2(18) *Agrostis stolonifera*–*Glyceria fluitans* conditions nearer the flooded basin margin. The pattern reflects expected transitions along a turlough margin under high-water winter conditions.

3.3.4 Transect 6 Results

Only the northern section of Transect 6 was accessible in 2025 (Appendix D), capturing a sequence of marginal to wet turlough vegetation transitioning into reedbed 5(14). The transect began within 3(19) *Potentilla anserina*–*Potentilla reptans* vegetation, dominated by silverweed, creeping cinquefoil and creeping bent. Occasional meadowsweet, curled dock and creeping buttercup were also present, consistent with a shallowly inundated intermediate community.

Further along the transect, conditions became wetter and shifted into 2(18) *Agrostis stolonifera*–*Glyceria fluitans* vegetation, where creeping bent and water forget-me-not were dominant. This community contained frequent reed canary-grass (*Phalaris arundinacea*), marsh bedstraw, water mint and lesser water-parsnip (*Berula erecta*), with abundant creeping cinquefoil. Standing water was noticeably deeper here than in the preceding section, consistent with a transition toward aquatic-influenced turlough habitat. At T6R2, the wet grassland community graded rapidly into a 5(14) reedbed dominated by branched bur-reed (*Sparganium erectum*) and lakeshore bulrush (*Schoenoplectus lacustris*) typical species of a turlough reedbed. This community marks a shift towards more frequently inundated conditions. No further communities were accessible beyond this point due to deep water.

Overall, the 2025 walkover of Transect 6 shows a strong hydrological gradient from moderately wet 3(19) swards to saturated 2(18) vegetation and ultimately to a structurally distinct 5(14) reedbed. This pattern reflects the persistence of high winter water levels and the close proximity of Transect 6 to the core turlough basin.

3.4 Comparative Results of Monitoring Years 2021 to 2025

3.4.1 Relevés

A summary of the relevé community results from survey years 2021 – 2025 is shown in Table 3-3. The raw relevé data for all years is found in Appendix F. Sharkey (2012) community types recorded in accessible relevés across all survey years are presented, allowing changes and consistency in vegetation communities to be tracked across the monitoring period.

Across the fixed-point relevés (2021–2025), intermediate communities dominate. The most common community types recorded were 3(19) *Potentilla anserina*–*Potentilla reptans* and 3(4) *Agrostis stolonifera*–*Potentilla anserina*–*Festuca rubra*, with the balance between these two varying between years.

Within Transect 2, relevés 12 and 16 remained 3(19) whenever surveyed. Relevé 2, located at the turlough margin alternated between intermediate 3(19) (2021, 2024) and terrestrial 7(15) *Lolium perenne*–*Trifolium repens*–*Agrostis stolonifera* (2022 and 2025), indicating shifts in moisture around edge habitat. Relevé 4 shifted from aquatic aligning, 5 (11) *Pericaria amphibian* – *Mentha aquatica* community in 2021 to stable intermediate 3(19) community for the remainder of the monitoring scheme. Relevé 6 shifted from terrestrial aligning 7(15) in 2021 to 3(19) and 6(23) *Carex nigra*–*Scorzoneroide autumnalis*.

In Transect 4, relevé 5 recorded 3(19) in 2021, changed to 3(4) in both 2022 and 2024, and reverted to 3(19) in 2025. These shifts likely reflect changes in species' relative abundance between years. Relevé 10 showed a similar pattern, transitioning from intermediate aligning community 3(4) *Agrostis stolonifera*–*Potentilla anserina*–*Festuca rubra* in 2022 to aquatic aligning community 2(2) *Pericaria amphibian* – *Eleocharis palustris* community in 2024.

The Transect 6 series (R2, R6, R12, R18) was consistently 3(4) *Agrostis stolonifera*–*Potentilla anserina*–*Festuca rubra* community whenever surveyed.

Overall, the results show modest year-on-year variability, with localised aquatic incursions and occasional terrestrial phases. The dataset is characterised by a strong and persistent dominance of intermediate Group 3 communities throughout the 2021–2025 monitoring period.

The vegetation fluctuations observed between 2021 – 2025 align with rainfall data shown in Table 1-1. Years with exceptionally high summer rainfall, such as 2023 and 2025, correspond to increased representation of aquatic or wetter-phase communities and reduced site accessibility, while drier years favour more intermediate assemblages. Because both rainfall and vegetation show non-directional year-to-year oscillation and communities repeatedly return to intermediate Group 3 types following wet or dry seasons, the dataset supports interpretation of short-term hydrological variation rather than a long-term directional trend.

Table 3-3: Relevés survey community results each survey year (2021 – 2025)

The table is colour-coded by typical favourable habitat: yellow for usually terrestrial types, blue for usually aquatic, and grey for intermediate communities. Red cells with a diagonal strike indicate inaccessible relevé locations.

Relevé Year	T2 R2	T2 R4	T2 R6	T2 R12	T2 R16	T4 R5	T4 R10	T4 R16	T4 R18	T4 R22	T6 R2	T6 R6	T6 R12	T6 R16	T6 R18	
2021	3 (19)	5 (11)	7 (15)	3 (19)	3 (19)	3 (19)								3 (4)	3 (4)	3 (4)
2022	7 (15)	3 (19)	3 (19)	3 (19)	3 (19)	3 (4)	3 (4)			3 (4)				3 (4)	3 (4)	3 (4)
2023																
2024	3 (19)	3 (19)	6 (23)	3 (19)	3 (19)	3 (4)	2 (2)			3 (4)				3 (4)	3 (4)	3 (4)
2025	7 (15)				3 (19)	3 (19)										

3.4.2 Transects

To assess vegetation dynamics across the transects graphical analysis derived from Geographic Information System (GIS) mapping is used. Community extents were digitised and measured to two decimal places. The resulting graphs are displayed as 100% stacked bar charts to illustrate the proportional contribution of each community type, enabling clear comparison of shifts in community composition between years. Communities are colour coded by typical favourable habitat: yellow for usually terrestrial, blue for usually aquatic, and grey for intermediate communities.

Areas along the transects that were inaccessible due to high water levels are mapped as flooded habitat in GIS using the recorded transect lines, ensuring that the full transect length was represented accurately. As none of the transects were accessible at any point during the 2023 survey season, this year is excluded from all charts and comparative analyses. These descriptive visualisations allow assessment of spatial and temporal variation in vegetation community composition.

Transect 2

Community composition along Transect 2 varied across survey years (Figure 3-1). In 2021–2022, the transect supported a dominant intermediate mosaic, chiefly 3(19) *Potentilla anserina*– *Potentilla reptans* with local aquatic fringe segments 5(11) *Pericaria amphibia*–*Mentha aquatica*; 2(18) *Agrostis stolonifera*–*Glyceria fluitans*). In 2024, 3(19) expanded while 5(11) and 3(13) *Potentilla*–*Carex nigra* were absent; 2(18) was present in the south and 6(23) *Carex nigra*–*Scorzonoides autumnalis* occurred in small sections. In 2025, Flooded habitat occupied >50% of transect length (Figure 3-1), with residual intermediate and minor terrestrial segments.

These patterns are consistent with hydrology-driven zonation in turloughs, with flood duration and recession timing mediating year-to-year substitutions among wet grassland and aquatic-fringe units.

Transect 4

Across years, the northern section shows consistent transitions from terrestrial fringe (1(10)) to intermediate (3(19), 3(4)) and aquatic fringe (2(18)). In 2024, a previously mapped 2(18) segments at T4R10 corresponded to 2(2) *Pericaria amphibia*–*Eleocharis palustris* submerged in standing water, reflecting substitution within the shallow-water margin spectrum (Figure 3-2).

Flooded habitat dominated overall, approximately 70–80% in 2021 and 2025 and approximately 50% in 2022–2024—indicating lower-basin positioning and sensitivity to hydroperiod (Figure 3-2). Years with similar water levels yielded similar community expressions, and where changes occurred, they mostly remained within group (intermediate) (Figure 3-2).

Transect 6

Transect 6 exhibits extensive flooded cover, including complete inundation in 2023 and >90% in 2025 (Figure 3-3). Where accessible (southern end), 3(4) *Agrostis–Potentilla–Festuca* dominates, grading to 2(18) and 2(16) at the central channel. Aquatic communities vary by year (3(9) *Phalaris–Potentilla* in 2022–2024; 2(18) in 2021, 2025), with 5(14) reedbed expanding in 2025—consistent with longer water retention. Repeated inaccessibility of northern relevés supports a shift toward longer/late hydroperiods at this transect.

Overall, there is consistency across the community types and their zonation recoded at Transect 6, specifically within the southern end where more of the transect was accessible to survey.

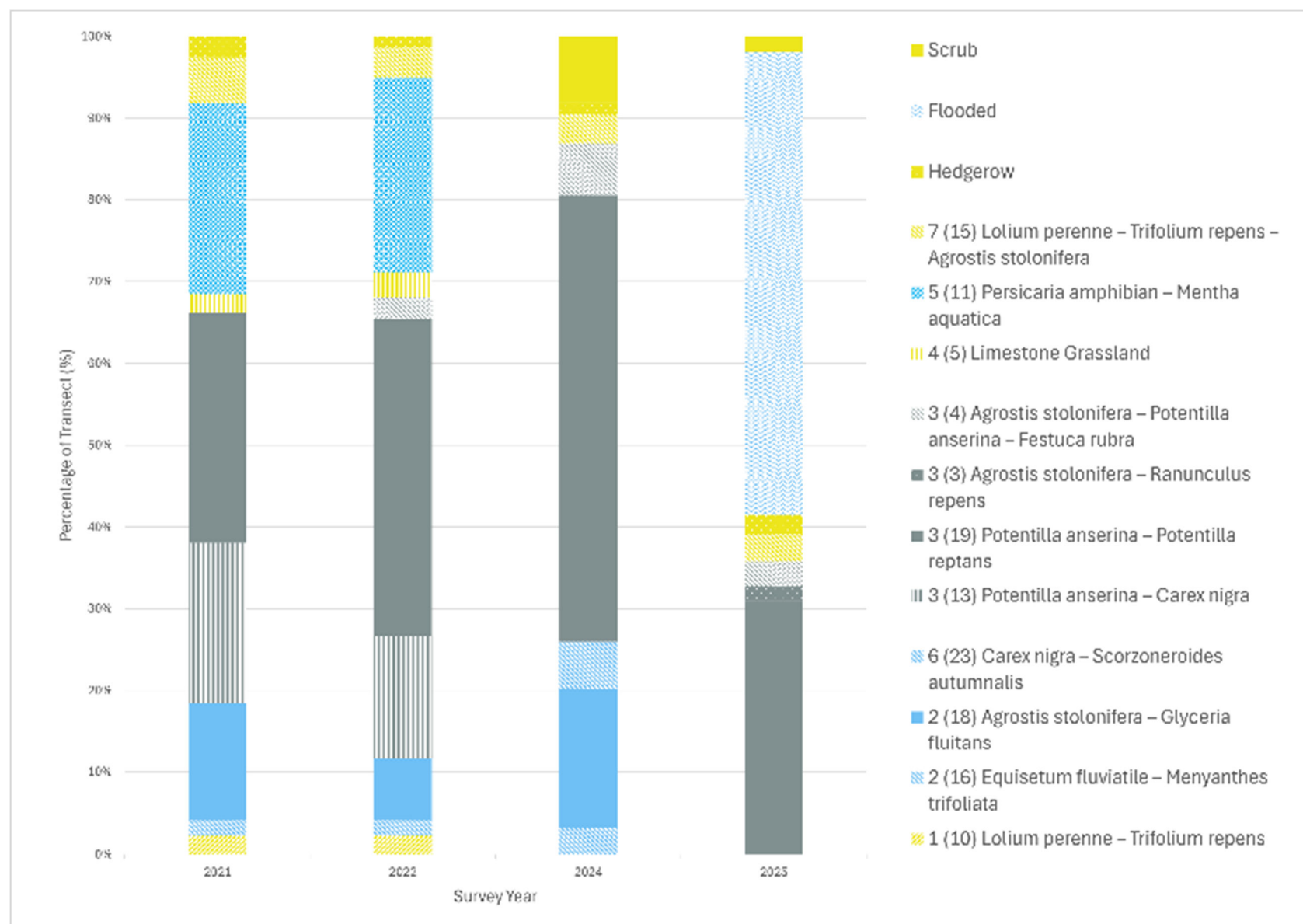


Figure 3-1: Transect 2 community composition percentages.

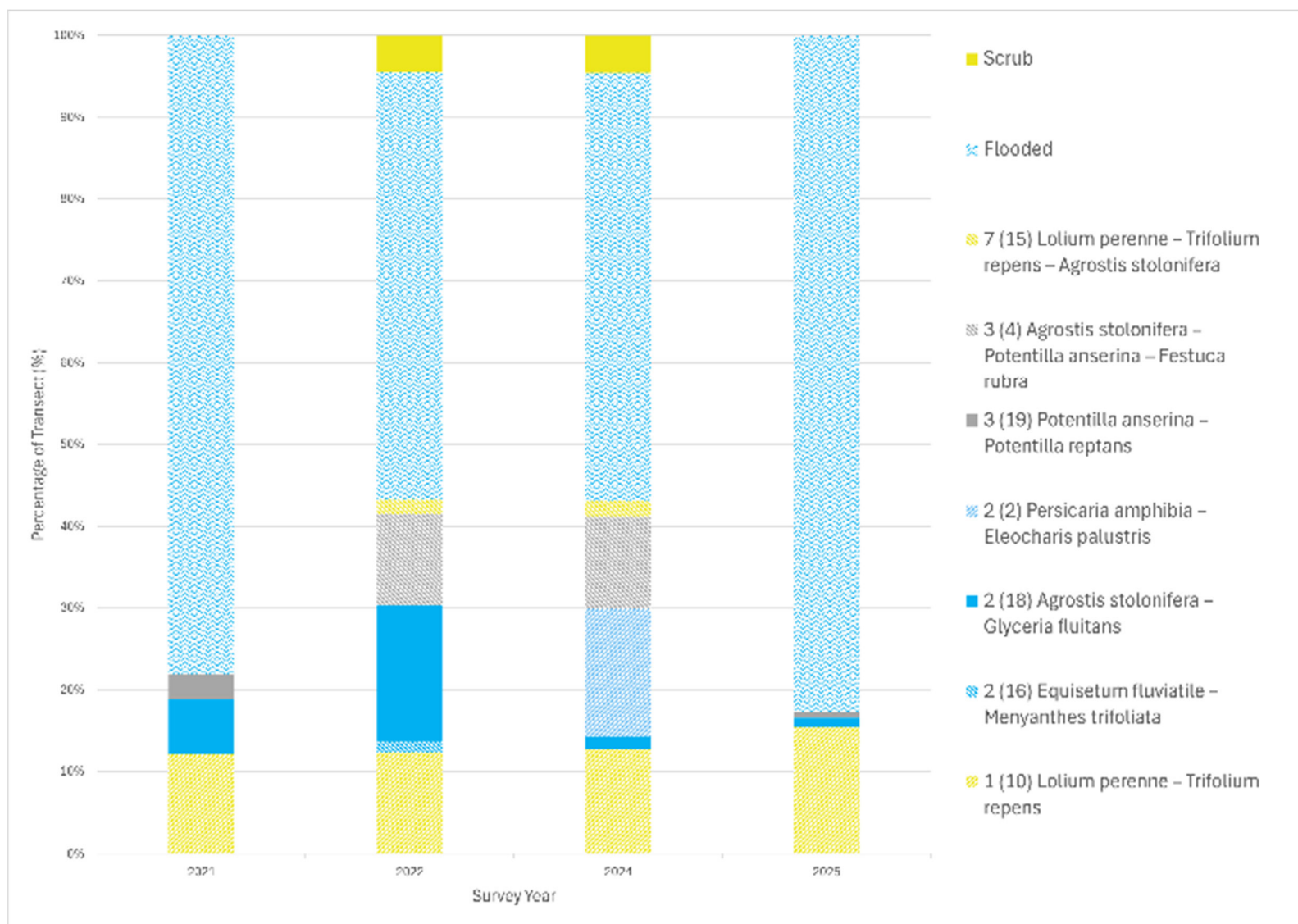


Figure 3-2: Transect 4 community composition percentages.

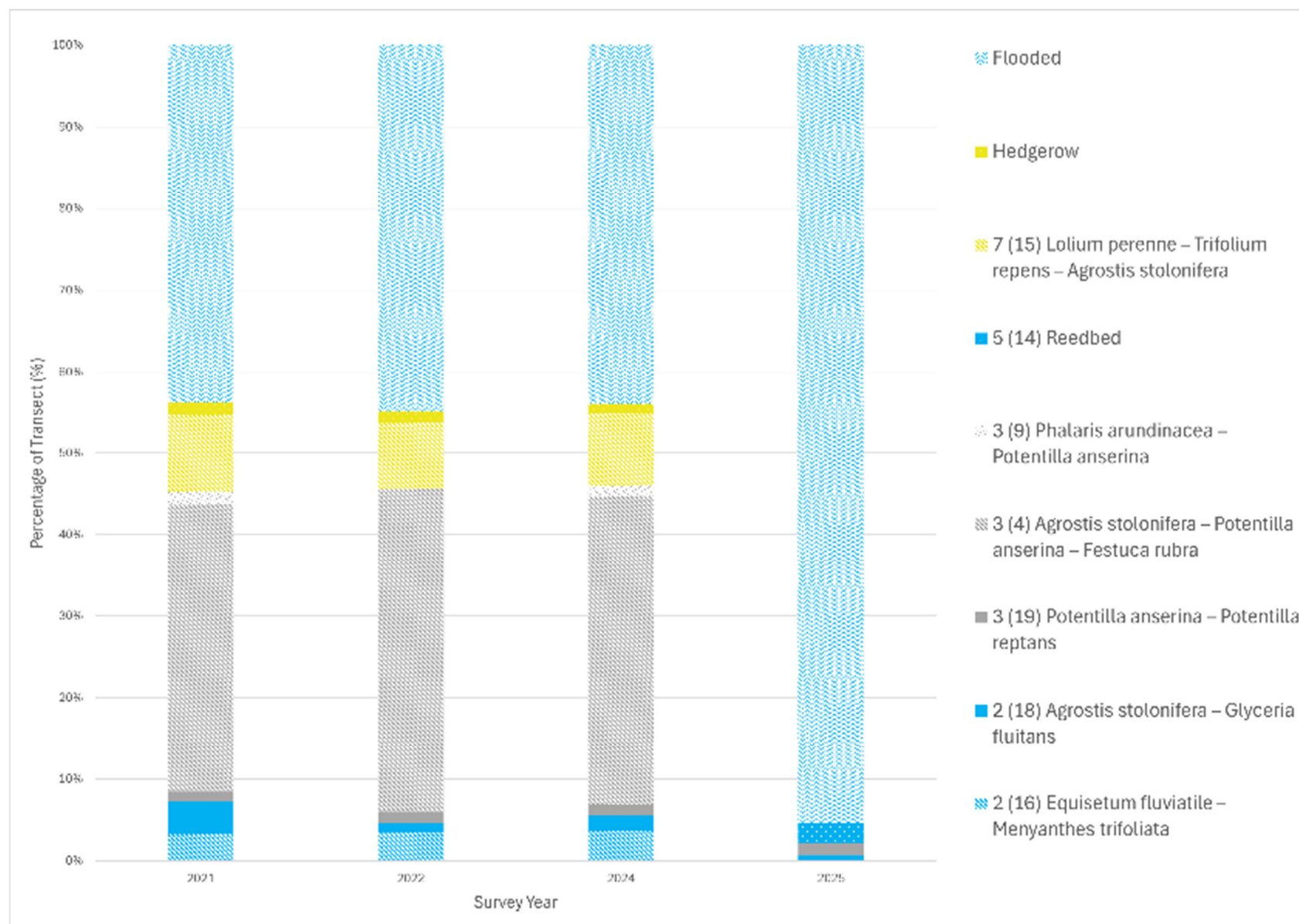


Figure 3-3: Transect 6 community composition percentages.

3.5 Comparison with RPS Survey Results

The original RPS (2016a) survey recorded a range of turlough vegetation communities along the relevé locations which were resurveyed over the duration of this monitoring scheme (Table 3-4). Communities included Limestone Grassland (5), a species-rich sward on shallow calcareous soils at the upper margins; intermediate wet grasslands such as *Potentilla anserina*–*Potentilla reptans* (19) and *Agrostis stolonifera*–*Ranunculus repens* (3), typical of intermediate damp zones; and aquatic fringe communities including *Agrostis stolonifera*–*Glyceria fluitans* (18), *Persicaria amphibia*–*Eleocharis palustris* (2) and *Persicaria amphibia*–*Mentha aquatica* (11), which occur in areas retaining shallow water into summer. These communities collectively indicate a mosaic structured by flood duration and depth, as described by Sharkey (2012).

Relative to the RPS baseline, Transect 2 remains similarly by intermediate aligning wet-grassland communities other than at the upper margin, with intermittent occurrences of aquatic fringe units (Table 3-4).

On Transect 4, replacement of wet grassland with a fully aquatic community is evident at T4R16 and T4R18, which consistently exhibited standing water across all monitoring survey years. At T4R10, elevated water levels were associated with fluctuation between intermediate and aquatic communities, whereas T4R22 showed a smaller transition within the intermediate category (from community 3 to 4) through time. By 2025, the transect was almost entirely flooded, leaving only minor terrestrial/intermediate remnants.

On Transect 6, multiple relevés that were aquatic in 2016 were repeatedly flooded/inaccessible in the later surveys, indicating prolonged inundation at those locations. In the more frequently accessible relevé positions on T6, the community type is consistent across monitoring years; although the classification differs from the RPS baseline, these positions have remained within an intermediate hydrological zone.

Taken together, the increased frequency of flooded records and the reappearance/substitution of water-margin communities indicate a potential shift toward extended or later hydroperiods, particularly along T6 and in the lower-basin portions of T4. This may reflect interannual variation in rainfall, with notably wet summers in 2023 and 2025 likely contributing to increased inundation compared to baseline conditions in 2014–2015 (Table 1-1; RPS, 2016).

Table 3-4: Relevé community results comparing monitoring survey years to RPS 2016 survey data.

The table is colour-coded by typical favourable habitat: yellow usually terrestrial, blue usually aquatic and grey for intermediate communities. Red cells with a diagonal strike indicate inaccessible relevé locations.

Relevé Study	T2 R2	T2 R4	T2 R6	T2 R12	T2 R16	T4 R5	T4 R10	T4 R16	T4 R18	T4 R22	T6 R2	T6 R6	T6 R12	T6 R16	T6 R18
RPS (2016)	5	19	19	18	19	19	18	2	2	3	11	11	3	19	19
2021 APEM	19	11	15	19	19	19							4	4	4
2022 APEM	15	19	19	19	19	4	4			4			4	4	4
2023 APEM															
2024 APEM	19	19	23	19	19	4	2			4			4	4	4
2025 APEM	15				19	19									

3.6 Comparison with Goodwillie (1992)

The vegetation communities defined by Sharkey (2012) correspond largely with the turlough community categories proposed by Goodwillie (1992). Communities recorded at Rahasane Turlough using Sharkey's classification system are shown with their corresponding Goodwillie (1992) communities in Table 3-5.

3.6.1 Terrestrial Fringe (dry edge and field margins)

Goodwillie's account describes extensive 2C Limestone grassland on outcropping limestone, with 2A *Lolium* grassland and 2B Poor grassland along flooded edges of agricultural fields and 5A Dry annuals on the north shore where trampling/over-wintering stock are concentrated.

Monitoring surveys (Sharkey framework) recorded the drier fringe communities 1(10) *Lolium perenne* – *Trifolium repens* (Goodwillie: 2A – *Lolium* grassland), 7(15) *Lolium perenne* – *Trifolium repens* – *Agrostis stolonifera* (Goodwillie: 2B – Poor grassland) and 4(5) Limestone grassland (Goodwillie: 2C – Limestone grassland) in marginal areas (Appendix E). Dry annuals equivalent to 5A were not recorded along the resurvey transects. This is consistent with a fringe that remains grazed.

3.6.2 Intermediate Communities

Goodwillie reports large expanses of 5B *Potentilla reptans* at both ends (particularly the southern basin), together with 6A Dry *Carex nigra* in the central southern section and 3B Sedge heath as a fringe below calcicole communities.

The 2021-2025 monitoring surveys find intermediate aligning communities strongly represented, principally 3(19) *Potentilla anserina*–*Potentilla reptans*, 3(3) *Agrostis*–*Ranunculus repens*, 3(4) *Agrostis*–*Potentilla*–*Festuca rubra*, 3(13) *Potentilla*–*Carex nigra* and 6(23) *Carex nigra*–*Scorzoneroide autumnalis*. These Sharkey (2012) communities correspond closely to Goodwillie's 5B, 6A, and 3B suite.

The core sward that Goodwillie described (*Potentilla*-rich with *Carex* variants) remains a dominant component in the resurveyed areas of Rahasane, indicating continuity of the middle-basin vegetation. Where within-category substitutions are recorded year on year (*Potentilla*-dominated shifting to *Agrostis*-dominated, or *Carex*-biased variants appearing), these shifts are consistent with no change in the hydrogradient (Sharkey 2012).

3.6.3 Aquatic and Water-margin Zone

Of the five aquatic aligning vegetation communities recorded during the 2021–2025 monitoring surveys, three correspond directly to communities documented by Goodwillie in 1992 (Table 3-5), demonstrating a continuity in the turlough vegetation structure over time. This overlap indicates that the fundamental community composition remains similar.

Two additional aquatic aligning communities were identified using Sharkey's (2012) classification, 6(23) *Carex nigra*–*Scorzoneroide autumnalis* and 2(16) *Equisetum fluviatile*–*Menyanthes trifoliata*. These have no direct equivalent in Goodwillie's typology, showing either finer resolution in the system adapted by Sharkey or localised conditions not previously captured. The presence of 5(14) reedbed also reflects a shift toward longer inundation periods in some specific areas.

Goodwillie documents a richly structured aquatic matrix:

- Wet margins: 7A & 8A *Polygonum amphibium* (*Persicaria amphibia*) communities; low-growing *Eleocharis palustris* in shallow winding channels potential precursors to 9A Temporary pond.
- Fully aquatic/pool complexes: 11B Peaty pond, 12 Open water, 10A *Oenanthe aquatica*, 10B Ditch margins, 9A Temporary pond, and 9B *Eleocharis acicularis* in the north-west pool; plus pondweed bands along the main river channel.
- Nutrient-influenced pockets where *Polygonum* (*Persicaria*) communities benefit from accumulations.

Monitoring years 2021-2015 recorded the same functional set but using Sharkey classification:

- Shallow-water/margin: 2(2) *Persicaria amphibia*–*Eleocharis palustris*, 5(11) *Persicaria amphibia*–*Mentha aquatica*, 2(18) *Agrostis*–*Glyceria fluitans*, 2(16) *Equisetum fluviatile*–*Menyanthes trifoliata*.
- Occasional substitutions within aquatic fringe for example between 2(18) and 2(2) at T4R10 under standing water, consistent with Goodwillie’s note that nutrient inputs and hydroperiod variation favour *Polygonum*/*Eleocharis* in pools and flood tracks.
- Reedbed 5(14) appearing locally, indicating sustained waterlogging or longer retention of water than in previously drier phases.
- Frequent “flooded/inaccessible” entries (especially on T6) at points that were aquatic in earlier mapping by RPS now submerged during several survey windows.

The aquatic communities Goodwillie described largely remain present. The resurveys capture more frequent and more extensive inundation at some of the same positions and within-aquatic substitutions (*Agrostis*–*Glyceria* to *Persicaria*–*Eleocharis*) patterns that most likely align with longer or later hydroperiods.

Table 3-5: Sharkey (2012) vegetation communities recorded along Rahasane Turlough Transects 2, 4 and 6, years 2021-2025, and their corresponding Goodwillie (1992) communities.

Turlough Vegetation Community Types Recorded by APEM Group, Woodrow (Cluster (Group)) (Sharkey, 2012)	Turlough Vegetation Community Types (Goodwillie 1992)	Habitat Affiliations	Community Recorded by Goodwillie
1 (10) <i>Lolium perenne</i> – <i>Trifolium repens</i> community	2A – <i>Lolium</i> grassland	Terrestrial	Yes
7 (15) <i>Lolium perenne</i> – <i>Trifolium repens</i> – <i>Agrostis stolonifera</i> community	2B – Poor grassland	Terrestrial	Yes
4 (5) Limestone Grassland	2C – Limestone grassland	Terrestrial	Yes
3 (9) <i>Phalaris arundinacea</i> – <i>Potentilla anserina</i> community	3A – Tall Herb	Intermediate	Yes
3 (3) <i>Agrostis stolonifera</i> – <i>Ranunculus repens</i> community	6A – Dry <i>Carex nigra</i>	Intermediate	Yes
3 (4) <i>Agrostis stolonifera</i> – <i>Potentilla anserina</i> – <i>Festuca rubra</i> community	3B – Sedge Heath	Intermediate	Yes
3 (19) <i>Potentilla anserina</i> – <i>Potentilla reptans</i> community	5B – <i>Potentilla reptans</i>	Intermediate	Yes
3 (13) <i>Potentilla anserina</i> – <i>Carex nigra</i> community	6B – Wet <i>Carex nigra</i>	Intermediate	No
6 (23) <i>Carex nigra</i> – <i>Scorzoneroideis autumnalis</i> community	N/A	Intermediate	No
2 (2) <i>Pericaria amphibia</i> – <i>Eleocharis palustris</i> community	7A – <i>Polygonum amphibium</i>	Aquatic	Yes
2 (16) <i>Equisetum fluviatile</i> – <i>Menyanthes trifoliata</i> community	N/A	Aquatic	No
2 (18) <i>Agrostis stolonifera</i> – <i>Glyceria fluitans</i> community	9A – Temporary Pond	Aquatic	Yes
5 (11) <i>Pericaria amphibian</i> – <i>Mentha aquatica</i> community	8A – <i>Polygonum amphibium</i>	Aquatic	Yes
5 (14) Reedbed	11A – Reedbed	Aquatic	No

3.7 Conclusions

Across the five years of monitoring (2021–2025), vegetation patterns at Rahasane Turlough show a stable three-band zonation: terrestrial fringe, intermediate wet grasslands and aquatic margins/flooded areas. Intermediate wet grassland communities remained dominant at accessible areas along all three transects (notably 3(19) and 3(4)), with annual variation expressed primarily as substitution within the same hydrological band (*Potentilla*-dominated wet grasslands shifting to *Agrostis*–*Potentilla*–*Festuca*, or aquatic fringe units exchanging between 2(18) and 2(2) under standing water), rather than blanket transitions to drier categories.

- Transect 2: A dominant intermediate mosaic persists across years, with local aquatic fringes expressed intermittently. 2025 recorded >50% of the transect as flooded, but the accessible segments remained intermediate or marginal terrestrial, consistent with hydrology-driven year-to-year reorganisation.
- Transect 4: The lower-basin setting is evident. Inundation forms the majority in 2021–2025, and an aquatic substitution at T4R10 (2(18) to 2(2) in 2024 is typical of shallow-water margin fluctuations. Where exposure allowed (2022–2024), 3(4) wet grassland community persisted; by 2025, the transect was almost entirely flooded.
- Transect 6: Northern relevés were repeatedly flooded/inaccessible, including complete inundation in 2023 and >90% Flooded in 2025. Where accessible (southern end), intermediate wet grassland 3(4) consistently dominated, grading to aquatic fringe 2(18) and 2(16), with reedbed 5(14) developing in the norther side in 2025, indicating longer water retention in that zone.

Taken together, the vegetation evidence indicates no systematic shift toward drier communities following completion of the flood relief scheme. The increased frequency and spatial extent of flooded/inaccessible records (especially on T6) are consistent with interannual variation in rainfall, including notably wet summers in 2023 and 2025 (Table 1-1; Figures 1-1 and 1-2), and aquatic community substitutions 2(18) for 2(2) are consistent with longer or later hydroperiods at parts of the site. However, given the interannual variation in rainfall during this period, it is not possible to distinguish any potential scheme-related effects from climatic influences with certainty.

This pattern accords with Sharkey's (2012) hydrology-driven zonation (community placement determined by flood duration, depth and recession timing) and remains coherent with Goodwillie's (1992) historical description of Rahasane Turlough's aquatic matrix and broad intermediate swards. The RPS (2016a) baseline comparisons further reinforce continuity in core communities, with wetter-year expressions reflected as flooded/inaccessible at several baseline relevé locations.

4 Macroinvertebrate and Pond PSYM Surveys

4.1 Background

Annual monitoring of freshwater macroinvertebrate communities and macrophyte communities has been conducted at Rahasane Turlough over the five-year period 2021-2025 to determine whether changes in their taxonomic composition has occurred that would suggest a transition from a habitat characteristic of being regularly flooded to one that is more frequently dry. Because turloughs are naturally ephemeral systems, variations in their hydroperiod occur from year to year. Therefore, identifying whether a genuine habitat transition is underway requires examining long-term patterns in community composition rather than short-term fluctuations.

The Predictive System for Multi-metrics (PSYM) is used as the standard survey approach for the turlough, enabling consistent comparison of results from year to year. The system was developed by the Freshwater Habitats Trust and the Environment Agency in England to assess the ecological quality of standing waters, and it provides a standardised methodology for annual turlough monitoring, incorporating both macrophyte and macroinvertebrate surveys (Howard, 2002).

In addition, water beetles were identified to species level to allow for comparison among years and with previous surveys conducted prior to the commencement of works at the site. The water beetle community of Rahasane Turlough has been surveyed on several occasions prior to this study, including records collected by Bilton in 1989, O'Connor in 2001, Waldron in 2003 and 2004 and RPS in 2016. These records are published in the pre-construction aquatic beetle survey (RPS, 2016b). Foster *et al.* (1992) established that aquatic Coleoptera possess range of attributes that make them valuable indicators for evaluating wetland conservation status. Their research identified ten distinct assemblage types of Irish water beetles and established a habitat classification system associated with these assemblages. Rahasane Turlough was assigned to Community Type F, described as “turloughs and more permanent, large, shallow water bodies on base-rich substrata” (Foster *et al.*, 1992). Foster and colleagues also developed a ranking system for assessing water beetle assemblages, enabling sites to be compared based on community significance and helping to identify wetlands of highest ecological value. Therefore, as part of this study water beetles were identified to species level and classified according to this system to facilitate comparison across survey years and with earlier assessments undertaken prior to the commencement of works at the site.

Standard metrics were calculated alongside PSYM outputs and were compared with results from the previous four years (APEM, 2021, 2023, 2024, 2025a). The presence and abundance of ephemeral taxa were also evaluated, drawing on the findings of Porst (2009), who reported that groups such as Trichoptera (caddisflies), Heteroptera (true bugs) and Gastropoda (snails) are more frequently associated with turloughs exhibiting longer hydroperiods. Gastropods, in particular, tend to occur in higher numbers in such systems.

4.2 Review of previous datasets and reports

The following sources of site-specific data were reviewed:

- RPS (2014a). *Environmental Impact Statement (Dunkellin River and Aggard Stream Flood Relief Scheme)*;
- RPS (2014b). *Natura Impact Statement (Dunkellin River and Aggard Stream Flood Relief Scheme)*;
- RPS, (2016b). *Dunkellin River and Aggard Stream Flood Relief Scheme: Pre-construction Aquatic Beetle Survey*;
- Annual APEM reports on surveys conducted from 2021-2024 (APEM, 2021, 2023, 2024 and 2025a)

- APEM (2025b). *Rahasane Turlough nutrient investigation final report*.

The following additional sources of relevant publicly available data and information were also reviewed:

- Environmental Protection Agency (EPA web-based data viewer (EPA map viewer; Water))
- National Parks and Wildlife Service (NPWS) web-based data viewer (Special Areas of Conservation; Special Protection Areas).
- National Biodiversity Data Centre Database
- Porst, 2009. *The Effects of Season, Habitat, Hydroperiod and Water Chemistry on the Distribution of Turlough Aquatic Invertebrate Communities*. PhD Thesis, Trinity College Dublin.
- Relevant published peer reviewed papers associated with turlough macroinvertebrate community composition (Foster *et al.*, 1992; Lahr, 1997; Lahr *et al.*, 1999; Follner and Henle, 2006 and Williams, 2006).

4.3 Method

The fifth of five annual surveys was conducted on 25 September 2025. Methods from the four previous annual surveys are described in each previous report (APEM, 2021, 2023, 2024 and 2025a).

4.3.1 Physico-chemical measurements

Temperature, pH, conductivity, turbidity and dissolved oxygen concentration and saturation were measured on-site on 25 September 2025 at each sample location using a multiparameter probe. . The probe was held in the water column, where the depth allowed. Where the water was shallow and the probe rested on the substrate, the substrate was given time to settle before readings were taken. Additional information on the local environment, substrate, shading, level of grazing and emergent plan cover was also recorded.

4.3.2 Macroinvertebrate survey and analysis

Macroinvertebrate sampling was carried out at four locations at the Rahasane Turlough on 25 September 2025 (Appendix G, Figure G-1). Owing to the high water levels, some of the previous sites were inaccessible (Sites 1 and 3) and thus these sites were moved to more accessible points. Site 1 was northwest of the original sampling point, on the northern shore, as the southern bank was inaccessible anywhere near this point. Site 3 was moved east to the nearest accessible point. Photos of the survey locations can be seen in Plates 8 to 11.

The survey was conducted by sweep netting through the submerged vegetation at all mesohabitats present at each location, using a standard pond net with 1 mm mesh size for a period of 45 seconds at each site (bringing the total to a 3-minute sample), as outlined in the PSYM method by Howard (2002). The samples were preserved in > 90% Isopropyl alcohol on-site and returned to the laboratory for further analysis, where they were combined into a single composite sample. An additional targeted aquatic beetle combined sample was selectively collected from a number of isolated pools around the turlough by sweep netting through submerged vegetation at all mesohabitats present using a small handheld pond net with 1 mm mesh size for a period of 30 seconds at each site, in order to maximise the number of species encountered; this method was also used in 2022, and was a slight adjustment to the 2021 method, following an external review of the first year's sampling programme. This sample was preserved in > 90% Isopropyl alcohol on-site and returned to the laboratory for further analysis.

Specimens were identified under a binocular microscope to family level in the laboratory using the standard range of identification keys published by the Freshwater Biological Association, AIDGAP and others, with the exception of water beetles, which were identified to the finest resolution possible

(species level where possible). A list of the macroinvertebrate taxa recorded can be found in Table 4-2 of this report. This list informed the calculation of all macroinvertebrate indices.

4.3.3 Plant survey and analysis

Pond macrophytes were surveyed in three of the five years of the project, namely 2021, 2022 and 2024, when conditions were suitable. This was conducted by wading the perimeter of the dry and shallow water areas at each of the four locations, with deeper areas sampled using the pond net. Species were recorded on the PSYM plant recording sheet as outlined in Howard (2002).

Macrophyte surveys could not be conducted in 2023 or 2025, as water levels were very high, making the previously surveyed permanent and semi-permanent pools where macrophytes would be observed inaccessible. Accessible survey points on the turlough were inundated grassland, where no macrophytes would be expected to occur.

4.3.4 Metrics calculation

PSYM was calculated for Rahasane Turlough based on the assessment of macroinvertebrate assemblages present as well as environmental data. PSYM is a predictive tool, comparing observed species assemblages with expected composition based on the type and location of the water body, and metric scores are then combined to provide a single value which summarises the overall ecological quality of the water body. However, the reference data used to enable the prediction is currently only available for England and Wales. Instead, the survey metrics are here compared to one another over five consecutive years, to identify any changes over this time.

For the macroinvertebrate samples, the metrics calculated for invertebrates in PSYM are Biological Monitoring Working Party (BMWP) score, Average Score Per Taxon (ASPT), the number of dragonfly and alderfly (Odonata and Megaloptera) families (OM) and the number of beetle families (Coleoptera).

The BMWP and ASPT scores exploit the natural sensitivity of each taxon to organic pollution, and were originally designed for use in flowing waters, despite their use as part of the Pond PSYM array of macroinvertebrate metrics. Macroinvertebrate families which are sensitive to pollution are assigned high BMWP scores, while pollution-tolerant taxa score low. BMWP index may be altered significantly depending on whether the sampling process captures species found in some habitats but not in others. Standardisation of the BMWP score is therefore provided by the ASPT, allowing robust comparisons among sites. BMWP was developed in the UK and has since been adapted for a range of locations globally, including Iberia (BMWP-I) and Costa Rica (BMWP-CR); the original version works well in Ireland.

Although the PSYM method recommends that pond quality should be assessed using both plant and invertebrate assemblages, it is stated that a partial assessment can be made using just one assemblage if necessary, and that macroinvertebrates are likely to be the best choice of organisms for assessing overall water body quality (Howard, 2002).

An EPA Q value classification was assigned to each site, and the Whalley Hawkes Paisley Trigg (WHPT) NTAXA (number of taxa) and WHPT-ASPT were also calculated. The Q value and WHPT metrics are designed for use on samples collected from rivers and so have limitations when applied to samples from standing waters, particularly as these are often naturally subject to low oxygen concentrations and have different assemblages of taxa to rivers. The Q values were assigned based on the presence and relative abundance of sensitive groups and the consideration of additional qualifying criteria, as described by Toner *et al.* (2005), and in Feeley *et al.* (2020), outlined in more detail in Appendix 2. .

The WHPT is an enhancement of BMWP, now used in the UK for monitoring, assessing and classifying rivers in accordance with the requirements of WFD.

Many of the metrics incorporating macroinvertebrates as bioindicators use a species or overall community's response to levels of dissolved oxygen to assess impact. This makes their use in standing waters less robust, so other measures of ecological health or value are needed, such as the presence/absence of particular species. In addition, given that much of Rahasane Turlough is ephemeral, the samples collected are likely to have quite distinct assemblages. However, the metrics can still be useful as a means of comparison of samples taken from the same water body over time and were calculated here on that basis. In the case of the Q value assigned, a corresponding WFD Ecological Status was not assigned, given that this metric is being used as a means of comparison among years and is not designed for use in still waters.

More details about Q value, BMWP and WHPT metrics is given in Appendix I.

4.3.5 Assessment using water beetles

Aquatic beetles were identified to species level and classified using the system outlined in Foster *et al.* (1992). This involves calculating Individual Species Quality Scores (SQS), assigned based on how commonly or rarely the species occurs in certain habitat types, and is based on an initial study that looked at their frequency within 10 km squares across Ireland. The scores of elusive species are downgraded, as are those associated with tidal water or confined to habitats of man-made origin. The scores of species restricted to undisturbed natural habitats are upgraded within the system. Then a Mean Quality Score (MQS) for a site is calculated by dividing the total of individual SQS by total number of scoring species. The MQS was calculated for each of the surveys conducted by APEM in 2021, 2022, 2023 and 2024. The MQS was also calculated for each of the pre-construction surveys, using the species lists provided in the report by RPS (RPS, 2016b). This enabled a comparison of MQS to be made over time.

4.4 Results and Discussion

4.4.1 Site description

In 2025, all sampling sites were inundated grazed pastures, with submerged and emergent aquatic plants absent at all sites, and floating leaved plants absent at all sites except Site 4, where 20% cover of *Lemna* sp was recorded. However, inundated terrestrial tall herbs were visible above the water surface, and the habitats present lacked heterogeneity. Water levels were high for this time of year, and therefore the permanent pools within the turlough were too far from the shore to sample. All sites were grazed intensively. Site descriptions for 2021-2024 are provided in each previous report (APEM, 2021, 2023, 2024 and 2025a).

4.4.2 Water quality

Key water chemical parameters from 2021-2025 are summarised in Table 4-1. The years 2023 and 2025, when temperatures were lower, are years recording heavy rainfall all summer and with high water levels in the turlough.

Dissolved Oxygen (DO) saturation % ranged from 85-101% at three of the sites in 2025, (with one site supersaturated at 130%). The saturation levels were again similar to those recorded in 2023 (84-105%). In contrast, high levels of saturation (supersaturation) were recorded in the years 2022 and 2024, while in 2021, DO saturation was low (29-51%). Years when supersaturation was recorded coincide with warmer years, when water levels were lower and more permanent pools were sampled,

with submerged plants and algae present; photosynthesis from these groups is likely to be the cause of the supersaturation.

Conductivity levels in 2025 were similar to previous years, aside from in 2024, when it was slightly lower at all sites. The pH of all sites was alkaline in almost all years, as would be expected in a turlough, given its Karst nature. However, in 2021 the pH was recorded more circum neutral; when this is considered alongside the reduced dissolved oxygen, it may have resulted from the decomposition of excessive vegetation or algal growth owing to nutrient enrichment increasing carbon dioxide production and lowering pH through carbonic acid formation); however, a subsequent nutrient investigation was inconclusive (APEM, 2025b). Turbidity was not recorded in all years owing to instrument error. However in the years 2021, 2024 and 2025 when it was recorded, it was low at most sites, with the exception of Site 3.

Table 4-1: Summary of *in situ* physicochemical data at Rahasane Turlough 2021- 2025

Colour codes indicate readings outside Dissolved Oxygen (DO) limits (80-120% saturation) set out in the Surface Water Regulations (2009); Blue: 25- 50% below lower limit; dark blue: 50-100% below lower limit; yellow: 1-25% above upper limit; orange: 25-50% above upper limit; red: >50% above upper limit.

Parameter	Unit	Year	Site 1	Site 2	Site 3	Site 4
Temperature	°C	2025	14.4*	14.0	13.1*	12.6
		2024	20.4	19.7	20.9	21.5
		2023	14.9*	15.0	15.0*	14.1
		2022	24.3	22.9	24.4	21.9
		2021	23.4	24.1	21.2	22.9
Dissolved Oxygen	% Saturation	2025	92*	130	101*	85
		2024	163	104	134	185
		2023	94*	105	105*	84
		2022	181	162	192	172
		2021	48	51	29	43
Dissolved Oxygen	mg/L	2025	9.4*	13.5	10.7*	9.2
		2024	14.7	9.5	12.0	16.4
		2023	9.5*	10.5	10.5*	8.6
		2022	15.2	14.0	16.2	16.1
		2021	4.1	4.3	2.5	3.6
Conductivity	µS/cm	2025	498*	546	625*	565
		2024	301	349	338	372
		2023	481*	552	552*	554
		2022	254	996	424	522
		2021	656	577	659	631
pH		2025	8.0*	8.2	7.5*	7.6
		2024	9.0	8.5	8.1	9.1
		2023	n/a	n/a	n/a	n/a
		2022	9.4	8.4	8.4	8.3
		2021	6.7	6.3	6.3	6.4
Turbidity	NTU	2025	9.2*	2.6	5.2*	1.8
		2024	3.2	4.6	12.4	1.0
		2023	n/a	n/a	n/a	n/a
		2022	n/a	n/a	n/a	n/a
		2021	6	6.4	5.7	6.0

*The locations of Sites 1 and 3 were moved in 2023 and in 2025 as they were inaccessible as a result of high water levels. In 2023, Site 1 was southwest of the original sampling point and Site 3 was moved to the northern shore, halfway between Sites 2 and 4 as the southern bank of the turlough was completely inaccessible. In 2025, Site 1 was northwest of the original sampling point, on the northern shore, as the southern bank was inaccessible and Site 3 was east of the original sampling point, to the nearest accessible point. Figure G-1 (Appendix G) shows a map of the locations of the different Sites in each year.

4.4.3 Taxonomic richness

Among the four sites surveyed, 28 families from 14 orders of macroinvertebrate taxa were identified in 2025 (Table 4-2), similar to richness recorded in 2024, and higher than the previous years (2021-2023). Notably, it was considerably higher than that recorded in 2023, when water levels were similarly high, and where samples were also collected in areas far from where the more permanent pools are situated. This difference between results in 2023 and 2025 could be as a result of where the sites were moved to. Site 1 in 2023 was a long distance from the permanent pools within the turlough, whereas this site was moved to the northern shore in 2025 and was not a great distance to the permanent channel within the turlough.

Similar to all previous years, the 2025 sample was dominated by aquatic gastropod snails, with very high numbers of Planorbidae and Lymnaeidae in particular. Planorbidae numbers have increased proportionally and in absolute numbers over time, reaching 37% of all invertebrates in 2025. Lymnaeidae numbers were high again in 2025, despite having declined previously from a high in 2021 to being almost absent in 2024. Bithyniidae were absent in 2023 but common in all other years. Overall, the sample was comprised of over $\geq 80\%$ of gastropods in 2025, similar to 2021 and 2022, contrasting with 2023 (44%) and 2024 (52%). High abundances of gastropods in turloughs have been associated with longer hydroperiods (Follner and Henle, 2006).

The other group that was common in most years was Crustacea. There were, however, lower numbers of the freshwater louse *Asellus aquaticus* (Asellidae) and the non-native shrimp *Crangonyx pseudogracilis* (Crangonyctidae) in 2025 than recorded in the previous two years. These crustaceans combined comprised 35% of the sample in 2024 and 29% in 2023, compared with only 3% in 2025. It is possible that *C. pseudogracilis* has recently colonised Rahasane Turlough, as it was not recorded in 2021 or 2022.

In a study of Irish turloughs, caddisflies (Trichoptera) and true bugs (Hemiptera) abundances were found to have a significant positive correlation with the hydroperiod of the turlough (Porst, 2009). Despite being ephemeral residents of temporary waters, these macroinvertebrate groups need more permanent habitats to complete their life cycles (Lahr, 1997; Lahr *et al.*, 1999). A large increase in the abundance of caddisflies was reported in 2025, with one additional family also recorded. Previously, only a small number of caddisflies had been recorded at the turlough in 2021 and 2024, and they were absent in 2023 and 2022. No notable relationship between their abundance and the extent of turlough flooding from 2021-2025 was observed. Nevertheless, their fluctuating numbers and high abundance in 2025 confirms that the community structure of the macroinvertebrates in the turlough constantly changes, changing hydroperiods year on year has not negatively affected caddisfly populations, and that permanent habitats are available to them.

Table 4-2: Macroinvertebrate taxa and their abundance recorded at Rahasane Turlough 2021-25.

Colour codes where proportional abundance is high: Yellow: 10-20% of sample; orange: 20-30%; red: 30-40%;

Order/Class	Family	Abundance				
		2021	2022	2023	2024	2025
Planaria	Planariidae	4				1
	Dendrocoeliidae	1				
Oligochaeta	Lumbricidae	22		2		
	Lumbriculidae				1	
	Naididae				17	2
Hirudinea	Glossiphoniidae	1	3		17	1
	Erpobdellidae	2			6	
Gastropoda	Valvatidae		85	10	3	70
	Bithyniidae	945	355		420	521
	Lymnaeidae	991	499	306	30	1027
	Planorbidae	413	410	795	834	1398
	Physidae	79	69	93	53	101
	Hydrobiidae				26	4
Bivalvia	Sphaeriidae	18	111		30	
Isopoda	Asellidae	24	13	474	510	75
Amphipoda	Crangonyctidae			309	420	29
	Gammaridae	8	10			5
Ephemeroptera	Baetidae	1	4	9		44
Odonata	Coenagrionidae	60	60	10	51	34
	Aeshnidae				6	
Hemiptera	Gerridae	1			3	
	Veliidae		5		14	
	Notonectidae		2		9	13
	Nepidae				9	
	Hebridae				1	
	Corixidae	200	38	108	6	128
Trichoptera	Hydroptilidae					1
	Leptoceridae	4			5	60
	Limnephilidae	2				13
Diptera	Chironomidae	32	5	17	118	93
	Simuliidae				2	1
	Culicidae	3			3	
	Rhagionidae					2
	Sciomyzidae			1		
	Tabanini		1			
Lepidoptera	Pyalidae				9	3
Coleoptera	Halplidae	220	9	38	25	14
	Dytiscidae	1	8	568	12	125
	Helophoridae		6	1	2	
	Hydrophilidae		1			6
	Chrysomelidae				1	2
	Hydraenidae				2	
	Elmidae				1	
	Dryopidae					1
	Curculionidae	1				
Total order/class		14	10	9	12	14
Total Families		24	20	15	32	28
Total Abundance		3,033	1,694	2,741	2,646	3,774

Hemiptera abundance increased in 2025 from 2024, driven by high numbers of Corixidae (water bugs). However, diversity decreased from six families in 2024 to two families in 2025. Diversity was low in the preceding years. Corixidae are known to colonise new habitats rapidly and the higher numbers of them in 2025 and 2023 might reflect higher water levels in these years, over areas which are not permanently flooded, however, this would not explain the high numbers in 2021. Overall, no consistent trends in the presence and abundance of Heteroptera is apparent among years, and they represented a small proportion of the sample in each year. However, while adults are able to disperse by flying, larval stages require permanent aquatic habitats and their continuing presence suggests that these are available to them.

Non-biting midge Chironomidae were recorded in higher relative abundance in 2024 and 2025 than in previous years, but no corresponding pattern in predators (e.g. Corixidae and aquatic adult beetles) was observed. They are omnivorous, ranging from grazing detritus feeders, scraping algae, or preying on smaller invertebrates (Armitage et al., 1995), and this may reflect an increase in food source.

There was a greater diversity of aquatic beetle families recorded in 2024 and in 2025 than in previous years. Aquatic beetles are discussed in more detail in Section 4.4.6 below. Numbers of damselflies (Coenagrionidae) was slightly lower than in previous years, with the exception of 2023. Dragonflies (Aeshnidae) were recorded in 2023 only.

Porst (2009) hypothesized that turloughs with longer habitat permanence have higher abundances of ephemeral taxa, because there is a greater possibility of colonisation. The proportional abundance of ephemeral taxa with high dispersal ability such as Odonata, Hemiptera, some Diptera, and some Coleoptera families (e.g. Dytiscidae) was 10.5% in 2025, which was similar to most previous years. The exception was 2023, when adult Dytiscidae dominated the ephemeral taxa. It is possible that the high numbers of Dytiscidae, and the differences in the taxonomic richness and the community assemblages in 2023 overall may be as a result of the distance of Site 1 from the main turlough in that year, owing to access issues (Appendix G, Figure G-1). However, samples from each site were pooled, in accordance with the PSYM method, and it is not possible to establish this.

No aquatic plant surveys were carried out in 2025 and 2023, as the permanent and semi-permanent pools previously surveyed where macrophytes would be observed were inaccessible and the accessible survey points were inundated grassland, where no macrophytes would be expected to occur, as previously discussed. However, in 2024, thirty nine taxa of aquatic plants were recorded among sites, identified to species, based on presence/absence, using the taxa list form provided by the PSYM method (Appendix 5). Forty seven taxa were observed in 2022 and twenty four in 2021, although a specialist botanist was not available in 2021, and it is possible that this result may be an underestimate.

4.4.4 PSYM Results

The Pond SYM metrics are presented in Tables 4-3 and 4-4. There were 28 PSYM macroinvertebrate taxa recorded in 2025, similar to 2024 and higher than all previous years and almost double the number recorded in 2023 (Table 4-3). The BMWP and corresponding ASPT were slightly higher than in previous years. However, the ASPT scores are relatively low overall, typical of standing waters, and reflecting the presence of very few taxa sensitive to organic pollution.

One Odonata and Megaloptera (OM) taxon, Coenagrionidae, was recorded present in 2025, 2023, 2022 and 2021, compared with two taxa recorded in 2024 (Coenagrionidae and Aeshnidae). Biggs *et al.* (2000) found that the OM metric had a strong correlation with environmental degradation in ponds and was a good indicator of water quality in British ponds. The presence of Aeshnidae, which had not been detected previously in the turlough, increased the score of this metric, suggesting an

improvement in ecological condition, in that year but should be examined in the context of all the metrics together.

The number of Coleoptera taxa (registering as PSYM scoring) were highest in 2025 and 2024. Overall, almost all scores improved over time and were at their highest value in 2025, suggesting an improvement in ecological condition at the turlough.

Table 4-3: Pond SYM macroinvertebrate metrics calculated at Rahasane Turlough

Metric	2021	2022	2023	2024	2025
BMWP	78	62	54	116	127
No of PSYM Taxa (NTAXA)	19	16	14	27	28
ASPT	4.11	3.88	3.6	4.29	4.53
No. of Odonata & Megaloptera Taxa (OM)	1	1	1	2	1
No. of Coleoptera Taxa (PSYM scoring)	2	2	3	4	4

The aquatic plant metrics are shown in Table 4-4, for the years that aquatic plants could be surveyed (2021, 2022 and 2024). The PSYM aquatic plant species recorded at the turlough are documented in Appendix 5. Biggs *et al.* (2000) found that emergent and submerged plant richness had strong correlations with environmental degradation. Taxa richness of these species varied over time, with less diversity in 2024 than in 2022, but more than in 2021. However, as previously stated, it is likely that species richness in 2021 was underestimated. The Trophic Ranking Score was slightly higher in 2024 than in previous years. Plants are scored based on their affinity to waters of a particular nutrient status, with higher scores associated with more nutrient rich conditions. Therefore, the slightly higher score in 2024 indicates the presence of more nutrient tolerant plant species than in previous years.

Table 4-4: Pond PSYM aquatic plant metrics calculated at Rahasane Turlough

Metric	2021	2022	2024
No. of Emergent & Submerged species	21	44	33
Trophic Ranking Score	8.35	7.97	8.62

4.4.5 Standard Macroinvertebrate Metric Results

The standard macroinvertebrate metrics are presented in Table 4-5 below. The number of families and the WHPT NTAXA were higher in the years 2021, 2024 and 2025 compared with 2022 and 2023, reflecting greater taxonomic diversity at the site in those years. The Q value score varied slightly among years. It was slightly lower in 2023 and 2024 than in other years. An ecological status assessment isn't appropriate based on the Q value as this metric is intended for use in rivers and is not used in assessing the ecological condition in standing waters. However, it does give an indication of changes in the composition of macroinvertebrates, and the lower scores in 2023 and 2024 represent an increase in taxa that are very tolerant of organic pollution (Group D).

The WHPT and WHPT-ASPT metrics are also intended for use in rivers and are based on the natural sensitivity of taxon to chemical changes in water, in particular to the changes in Dissolved Oxygen (DO) concentrations, based on empirical data. As pollution levels increase, the microbial oxygen demand rises, resulting in a decline in available oxygen concentrations. Many stream organisms require high dissolved oxygen concentration and are therefore not found in water bodies with lower oxygen

concentrations. Although the scores are not directly related to standing waters, where DO concentrations may be lower on the benthos owing to less water movement, and may fluctuate more in response to photosynthesis, respiration and decomposition, they nevertheless remain useful in detecting changes in taxonomic structure among years within the same water body.

Both the WHPT and WHPT-ASPT were higher in 2024 and 2025 than other years, albeit with low scoring overall. WHPT NTAXA similarly was lower in 2022 and 2023 than in other years. Overall, although ecological quality fluctuated among years, it appears to be stable over time.

Table 4-5: Standard macroinvertebrate metrics calculated at Rahasane Turlough

Metric	2021	2022	2023	2024	2025
Total no. Families	24	20	15	36	28
Q Value	Q3	Q3	Q2-3	Q2-3	Q3
WHPT	81.6	64.8	46.5	102.7	105.6
WHPT ASPT	3.4	3.6	3.1	3.7	4.2
WHPT NTAXA	24	18	15	28	25

4.4.6 Beetle Survey Comparison

Aquatic beetle species recorded at the site from 2021-2025 are presented in Table 4-6 and changes in the Mean Quality Score (MQS) over time are recorded in Table 4-7. Eleven species of adult aquatic beetles were recorded at the site in 2024, similar to the 12 species recorded in 2024 and ten in 2023. Only six taxa were recorded in 2022 and four in 2021. Since APEM surveys began in 2021, eight new aquatic beetle species have been recorded at the site, with one new genus (*Dryops* sp.) recorded in 2025; all are relatively commonly distributed in Ireland. Their associated Species Quality Scores (SQS) were calculated. This metric represents the conservation importance of the aquatic beetle species, ranging from 1-256, with higher score representing rarer species or those restricted to undisturbed, natural habitats (Foster *et al.*, 1992). The newly recorded taxa over the APEM survey period did not have high SQSs (≤ 16) and none of them were restricted to undisturbed habitats.

The highest scoring aquatic beetle recorded at the site was *Graptodytes bilineatus* with a score of 64, recorded by Waldron in 2004 (RPS, 2016b); this species is rare and restricted to undisturbed natural habitats (Foster *et al.*, 1992). The next highest scoring species was *Cercyon tristis*, with a score of 32, recorded by Waldron in 2003 (RPS, 2016b); though rare, it is not restricted to natural habitats (Foster *et al.*, 1992).

Beetle diversity over the five year period was higher from 2023-2025 than earlier years in the study period and similar to that documented in older studies (Table 4-6). The Mean Quality Score (MQS) varied over the five year study period, with the highest score recorded in 2025 and the lowest recorded in 2024. Overall the range of scores were similar to those in previous surveys, with the exception of the 1989 and 1992 which had exceptionally low scores. The highest MQS overall was recorded in 2004, owing to the presence of the aforementioned *G. bilineatus*. However, though the metric is useful, it was developed in the early 1990s and the rarity of each species was determined based on surveys conducted over thirty years ago. A more accurate picture of the conservation importance of the aquatic beetle species assemblage could be gained should the SQS method be updated with a more expansive and recent dataset.

Records of several aquatic beetle species sensitive to hydrological alterations were noted in the Environmental Impact Statement (EIS). These were the turlough species *Agabus nebulosus*, *Hygrotus*

quiquelineatus and *Hygrotus impressopunctatus*; and the moss dwelling species *Graptodytes bilineatus*. *G. bilineatus* is listed as Near Threatened on the Irish Water Beetle Red List (Foster *et al.*, 2009) and is considered likely to be vulnerable to disturbance and sensitive to alterations in flooding (Sheehy Skeffington *et al.*, 2006). As previously mentioned, it has only once been recorded at the turlough, in 2004, and has not been recorded since. As it was recorded on only one occasion it is not possible to attribute its absence or presence to any particular factor.

Table 4-6: Aquatic beetle species recorded in the 2021-2024 surveys of the Rahasane Turlough

The species in grey are noted in the Environmental Impact Statement as sensitive to hydrological alterations.

Family	Species / Species group	2021	2022	2023	2024	2025
Curculionidae		1				
Chrysomelidae	Larvae				1	2
Halipidae	<i>Halipus</i> sp. (larvae)	199			3	11
	<i>Halipus ruficollis</i> group	20	6	23	11	
	<i>Halipus immaculatus</i>				7	
	<i>Halipus lineolatus</i>	1	1	7		
	<i>Halipus ruficollis</i>		2	8	2	3
	<i>Halipus sibericus</i>				2	
Dytiscidae	Larvae			2		25
	<i>Hygrotus inaequalis</i>		3	14	1	2
	<i>Hygrotus quinquelineatus</i>			17		
	<i>Hygrotus impressopunctatus</i>			316		8
	<i>Hydroporus palustris</i>		5	199	8	81
	<i>Agabus nebulosus</i>			17		1
	<i>Colymbetus fuscus</i>				2	
	<i>Ilybius fuliginosus</i>	1				
	<i>Rhantus exsoletus</i>			1		3
	<i>Rhantus frontalis</i>			2	1	4
	<i>Rhantus suturelles</i>					3
Helophoridae (Hydrophilidae)	Larvae					1
	<i>Helophorus aequalis</i>			1		
	<i>Helophorus brevipalpis</i>				1	
	<i>Helophorus longitarsis/griseus/minutus</i>		3			
	<i>Helophorus minutus</i>		3		1	
	<i>Laccobius colon</i>		1			5
Dryopidae	<i>Dryops</i> sp.				1	1
Elmidae	<i>Elmis aenea</i>				1	
Hydraenidae	<i>Octhebius minimus</i>				2	

All three of the three turlough species *A. nebosus*, *H. quinquelineatus* and *H. impressopunctatus* were found in 2023, and two of the three species (*A. nebosus* and *H. impressopunctatus*) were found in 2025, albeit in much lower numbers than those found in 2023. These were years where water levels were high in summer. It is possible that high water levels in flooded very small isolated wetland pools where these species are more likely to occur, and that these species were encompassed into the

shallower edges of the main body of water in the turlough and thus were captured more easily. Site 1 was sampled quite a distance from the main turlough in 2023, whereas in 2025 it was close to the main body of the turlough, and perhaps the more distant pools had higher numbers of these species. The fact that these species have been found at the site in both wet years suggests that the flood relief scheme has not caused a hydrological change at the turlough.

Table 4-7: Mean Quality Score (MQS) calculated and number of aquatic beetle species surveyed at the Rahasane Turlough, in this survey (bold) compared with previous years⁷.

Year	MQS Score	No. of species	Surveyor
2025	8.2	11	APEM
2024	5.5	12	APEM
2023	6.0	10	APEM
2022	7.7	6	APEM
2021	6.7	3	APEM
2016	6.5	17	RPS
2004	10.4	13	Waldron
2003	7.5	12	Waldron
2002	5.7	10	O'Connor
1992	3.0	11	Foster
1989	3.3	11	Bilton

4.5 Conclusions

Although macroinvertebrate community assemblages differed among years, the continuing high proportional abundance of gastropod snails, associated with turlough with longer hydroperiods (Follner and Henle, 2006) suggests that the turlough remains inundated for long enough periods to allow their continued dominance.

The fluctuating numbers and high abundance of caddisflies (Trichoptera) in 2025 confirms that permanent habitats are available to them, and that their populations have not declined over the five year monitoring period.

Although no consistent trends in the presence and abundance of the true bugs (Heteroptera) is apparent among years, their continuing presence, albeit with fluctuations in their abundance and diversity (with high numbers of Corixidae in flooded years) suggest that permanent habitats are also available to them, and that this has not changed over the five year monitoring period.

Ephemeral taxa with high dispersal ability were recorded at similar levels among years, with proportional abundance higher in 2024 and 2025 than in previous years. Considering the hypothesis that turloughs with longer habitat permanence have higher abundances of ephemeral taxa (Porst,

⁷ MQS values for surveys conducted prior to the APEM survey period of 2021-2025 were calculated based on earlier records (species lists) reproduced in the RPS pre-construction aquatic beetle survey (RPS, 2016b).

2009), this suggests that these taxa have sufficient habitat permanence to persist, which has not decreased over the five year monitoring period.

PSYM macroinvertebrate scores improved over time, suggesting an improvement in ecological condition at the turlough, although in contrast plant scores suggested the presence of nutrient tolerant species and did not vary much among years. The turlough aquatic beetle species sensitive to hydrological alterations, namely, *Agabus nebulosus*, *Hygrotus quinquelineatus* and *Hygrotus impressopunctatus*, were also recorded in wet years. In conclusion, there is no evidence from the five year monitoring period that the turlough has changed from a regularly flooded habitat to one of a more frequently dry habitat.

5 Conclusions

There was no evidence from the surveys of a drying out of the Rahasane Turlough, nor of any apparent reduction in the extent and/or frequency of flooding of the turlough. This conclusion is based on the evidence of five years of annual surveys assessing the hydrogeology, hydrology, vegetation and macroinvertebrate communities, and with a focus on a number of sensitive communities and species, conducted as set out in Condition No. 4 of the planning permission granted for the scheme (07.JA0035).

Hydrogeology and Hydrology Survey:

The ecosystem associated with the Rahasane Turlough SAC is highly dependent on the hydrological flow regime at the site, which is, in turn, defined by the karst system (manifested by karst features such as caves, swallow holes, estavelles) underlying the turlough catchment. No obvious change in karst features during five year monitoring period was observed, based on walkover surveys and drone survey data. There appears to be no change in the hydrogeological regime of the Rahasane Turlough since implementation of the Dunkellin River and Aggard Stream Flood Relief Scheme.

Vegetation Surveys:

No systematic shift toward drier communities' post-FRS was observed, based on the evidence of the annual vegetation surveys. The increased frequency and spatial extent of flooded/inaccessible records is likely linked to increased amounts of rainfall recorded during summer and early autumn months. Aquatic community substitutions 2(18) for 2(2) are consistent with longer or later hydroperiods at parts of the site, aligning with a hydrology-driven zonation (community placement determined by flood duration, depth and recession timing) as described by Sharkey (2012) and with the historical description of Rahasane Turlough's aquatic matrix and broad intermediate swards (Goodwillie, 1992). Comparison with the RPS (2016) baseline surveys further reinforces the continuity of core communities, with several baseline relevé locations flooded/inaccessible during wetter years.

Macroinvertebrate Surveys:

There is no evidence from the five year monitoring of macroinvertebrate taxa that the turlough has changed from a regularly flooded habitat to one of a more frequently dry habitat. The community assemblages over the five-year monitoring period had consistently high abundances of Gastropoda, associated with long hydroperiods in turloughs, alongside taxa such as Trichoptera and Hemiptera that have a significant positive correlation with the hydroperiod of turloughs. Numbers and taxonomic composition fluctuated among years, but indicators of permanent standing water were consistently present, with highest numbers recorded in the final survey year, confirming that these taxa have permanent habitats available to them. Likewise, ephemeral taxa with high dispersal ability, associated with turloughs with longer habitat permanence, were recorded at similar levels among years, with proportional abundance higher in 2024 and 2025, suggesting that the habitat they require has not decreased over the five year monitoring period. Aquatic beetle species sensitive to hydrological alterations: *Agabus nebulosus*, *Hygrotus quinquelineatus* and *Hygrotus impressopunctatus*, were also recorded in wet years.

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Plates



Plate 1: ID: B10 Estavelle (left: 2023, right: 2025)



Plate 2: ID: A10 Existing well (left: 2021, right: 2025)



Plate 3: ID: A1 Enclosed depression (left: 2022, right: 2025)



Plate 4: Feature A8 Shallow Depressions (left: 2021 right: 2025)



Plate 5: Left: Possible swallow holes, dry; Right: swallow hole draining the Dunkellin channel.



Plate 6: D2 Very Large circa 200m diameter depression



Plate 7: D3 Large channel-shaped depression which loops and connects to D2 above



Plate 8: Photo of Site 1 (macroinvertebrate survey, 25.09.25)



Plate 9: Photo of Site 2 (macroinvertebrate survey, 25.09.25)



Plate 10: Photo of Site 3 (macroinvertebrate survey, 25.09.25)



Plate 11: Photo of Site 4 (macroinvertebrate survey, 25.09.25)

Plate 5:

Appendix A: Drawing 1 Hydrology and Hydrogeology Walkover Monitoring Locations



Map Legend

- Monitoring Locations
- 2021
 - 2022
 - 2024
 - 2025
 - Hydrometric Gauge (OPW)
 - Enclosed Depression (GSI)
 - Estaville (GSI)
 - Spring (GSI)
 - Swallow Hole (GSI)
 - Turlough (GSI)

Spatial Reference
Datum: IRENET10
Projection: Transverse Mercator



SITE LOCATION - NOT TO SCALE

Drawing Title:

Monitoring Locations		
Project Title		
Rahasane Turlough Monitoring		
Project No.	Drawing No.	Scale
240257	1	1:10,000
Drawn By	Checked By	Date
JB	BA	27/11/2025



Email: info@mkofireland.ie/ Website: www.mkofireland.ie

Appendix B: Vegetation Classification Systems

Table B- 1: Turlough vegetation classification system comparison

Dark grey cells denote Goodwillie (1992) Communities without corresponding Sharkey (2012) communities and vice versa.

Communities are colour-coded by **typical** favourable habitat conditions of their diagnostic species as follows: yellow: usually terrestrial, blue: usually aquatic, grey: intermediate.

Turlough Vegetation Community Types (Goodwillie 1992)	Turlough Vegetation Community Types (Cluster (Group)) (Sharkey, 2012)	Habitat Affiliations
2A – Lolium grassland	1 (10) <i>Lolium perenne</i> – <i>Trifolium repens</i> community	Terrestrial
2B – Poor grassland	7 (15) <i>Lolium perenne</i> – <i>Trifolium repens</i> – <i>Agrostis stolonifera</i> community	Terrestrial
2C – Limestone grassland	4 (5) Limestone Grassland	Terrestrial
2D – Peat grassland		Intermediate
2W – Dry Wood		Terrestrial
3A – Tall Herb	3 (9) <i>Phalaris arundinacea</i> – <i>Potentilla anserina</i> community & 6 (12) <i>Filipendula ulmaria</i> – <i>Vicia cracca</i> community	Intermediate
3B – Sedge Heath	3 (4) <i>Agrostis stolonifera</i> – <i>Potentilla anserina</i> – <i>Festuca rubra</i> community	Intermediate
3C – Flooded pavement	4 (28) Flooded Pavement	Intermediate
3W – <i>Rhamnus</i> Wood		Terrestrial
4B – <i>Potentilla reptans</i>	3 (20) <i>Filipendula ulmaria</i> – <i>Potentilla erecta</i> – <i>Viola</i> sp. community	Intermediate
4D – <i>Schoenus</i> Fen	4 (21) <i>Schoenus nigricans</i> fen	Intermediate
4W – Frangula Wood		Terrestrial
5A – Dry Annuals	1 (1) <i>Poa annua</i> – <i>Plantago major</i> community	Terrestrial
5B – <i>Potentilla reptans</i>	3 (19) <i>Potentilla anserina</i> – <i>Potentilla reptans</i> community	Intermediate
5D – Sedge Fen	6 (8) <i>Carex nigra</i> – <i>Carex panicea</i> community	Intermediate
5E – Cutover <i>Carex nigra</i>	8 (25) <i>Carex nigra</i> – <i>Carex viridula</i> community	Aquatic
6A – Dry <i>Carex nigra</i>	3 (3) <i>Agrostis stolonifera</i> – <i>Ranunculus repens</i> community	Intermediate
6B – Wet <i>Carex nigra</i>	3 (13) <i>Potentilla anserina</i> – <i>Carex nigra</i> community	Intermediate
6D – Peaty <i>Carex nigra</i>	6 (17) <i>Carex nigra</i> – <i>Ranunculus flammula</i> community	Aquatic

7A – <i>Polygonum amphibium</i>	2 (2) <i>Persicaria amphibia</i> – <i>Eleocharis palustris</i> community & 2 (7) <i>Eleocharis palustris</i> – <i>Phalaris arundinacea</i> community / <i>Eleocharis palustris</i> community	Aquatic
7B – Tall Sedge		Aquatic
8A – <i>Polygonum amphibium</i>	5 (11) <i>Persicaria amphibia</i> – <i>Mentha aquatica</i> community	Aquatic
8B – Wet Annuals		Aquatic
8C – <i>Cladium</i> Fen		Aquatic
9A – Temporary Pond	2 (18) <i>Agrostis stolonifera</i> – <i>Glyceria fluitans</i> community	Aquatic
9B – <i>Eleocharis acicularis</i>	1 (26) <i>Eleocharis acicularis</i> Community	Intermediate
9C – Marl Pond	5 (6) <i>Eleocharis palustris</i> – <i>Ranunculus flammula</i> community	Aquatic
10A – <i>Oenanthe aquatica</i>	5 (11) <i>Persicaria amphibia</i> – <i>Mentha aquatica</i> community	Aquatic
10B – Ditch		Aquatic
11A – Reedbed	5 (14) Reedbed	Aquatic
11B – Peaty Pond	2 (27) <i>Carex nigra</i> – <i>Equisetum fluvatile</i> community	Aquatic
12 – Open Water	5 (24) <i>Potamogeton natans</i> – <i>Glyceria fluitans</i> community	Aquatic
	6 (23) <i>Carex nigra</i> – <i>Scorzonoides autumnalis</i> community	Intermediate
	2 (16) <i>Equisetum fluvatile</i> – <i>Menyanthes trifoliata</i> community	Aquatic

Appendix C: Vegetation Monitoring Locations

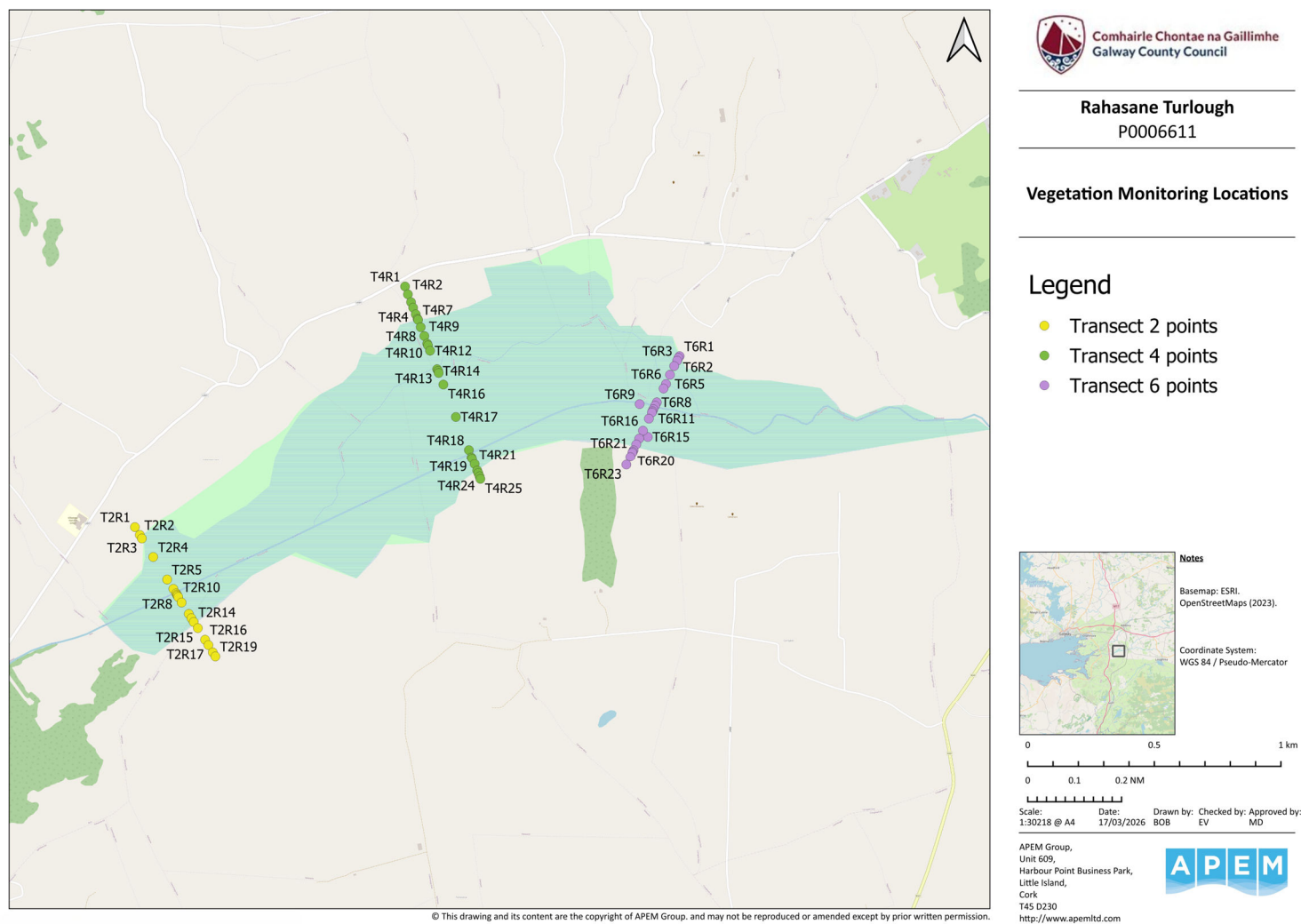


Figure C 1: Rahasane Turlough's monitoring transects

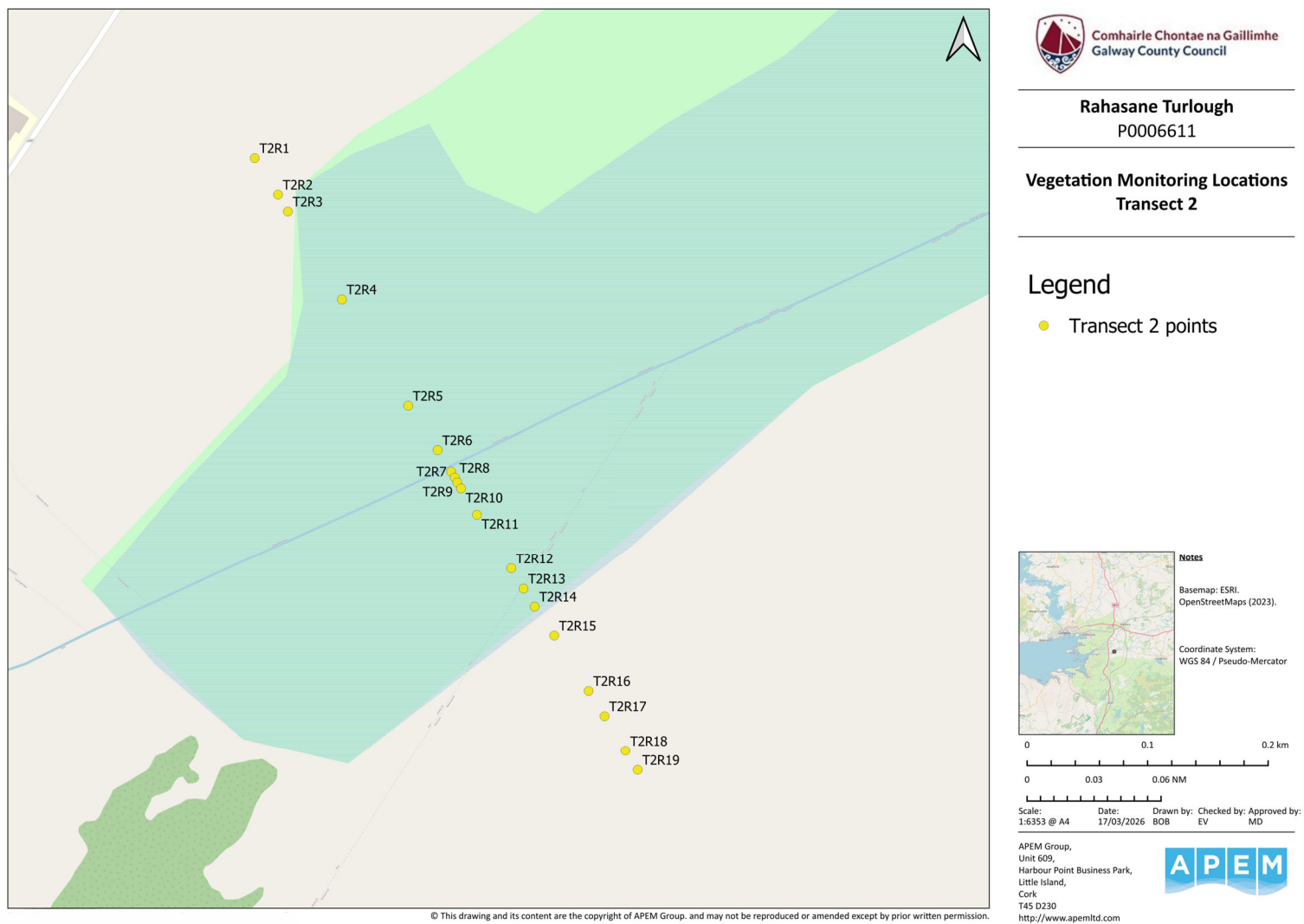


Figure C 2: -1: Rahasane Turlough monitoring transect 2

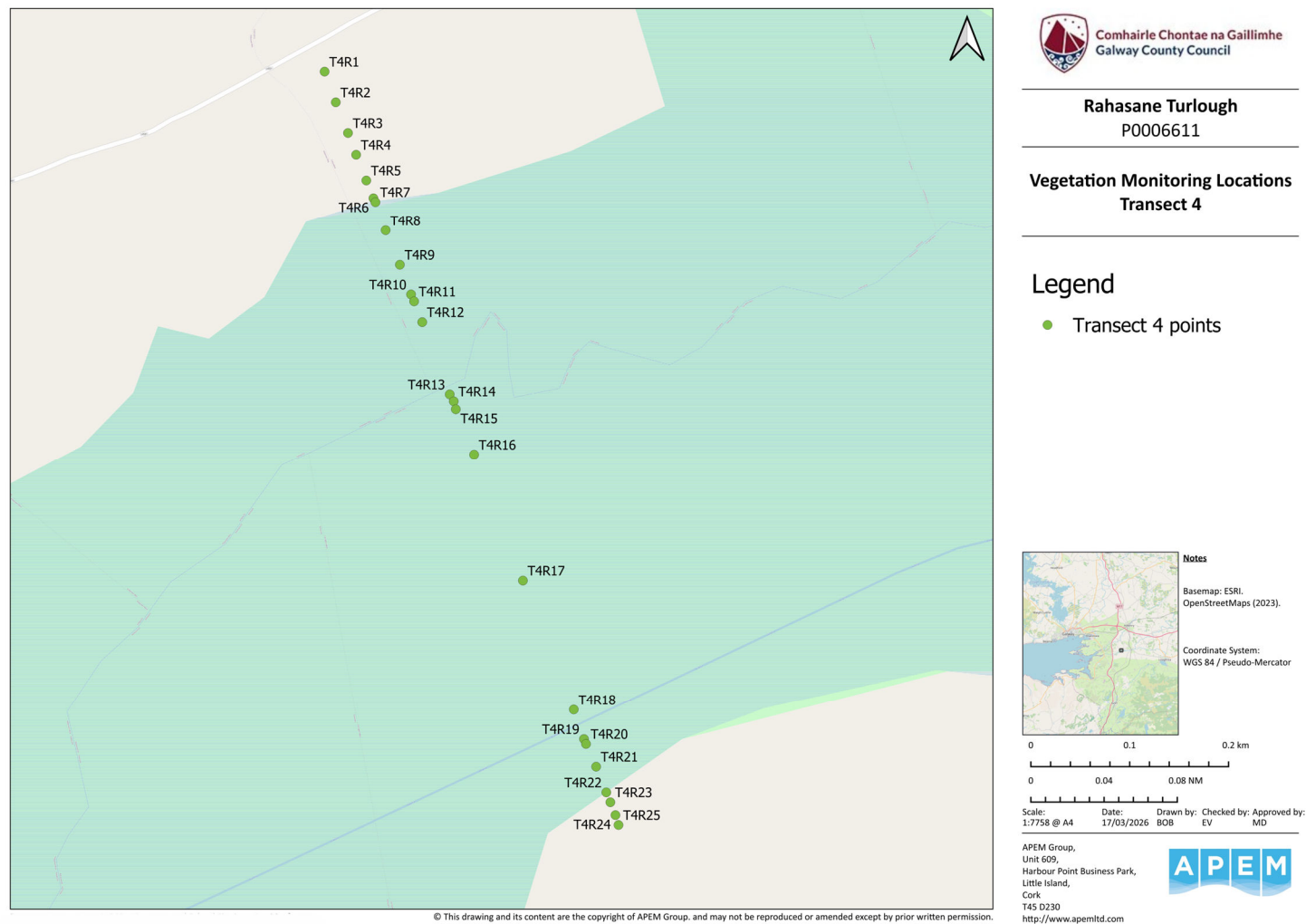


Figure C 3: Rahasane Turlough monitoring transect 4

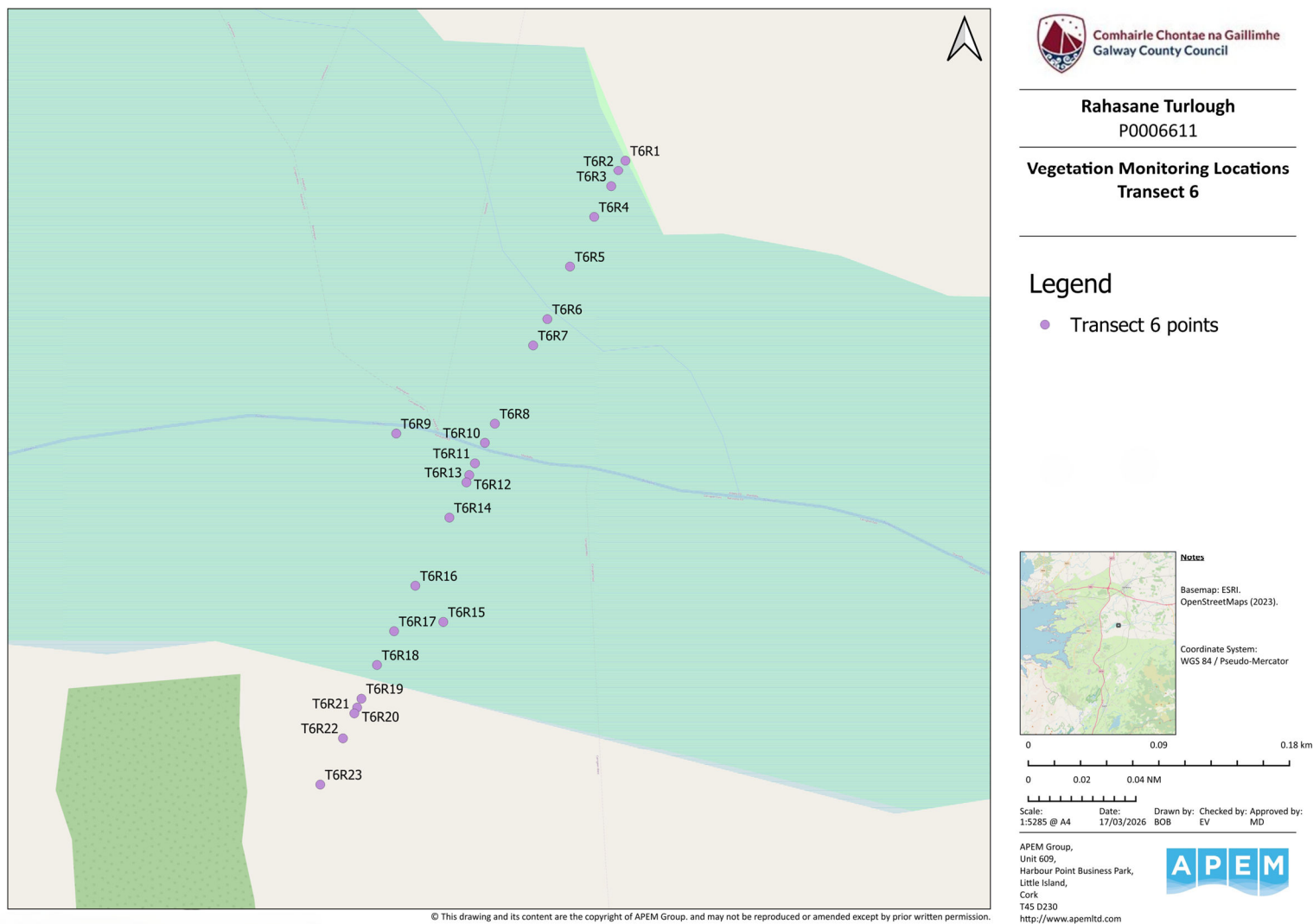


Figure C 4: Rahasane Turlough monitoring transect 6

Appendix D: Vegetation Transect Results 2025

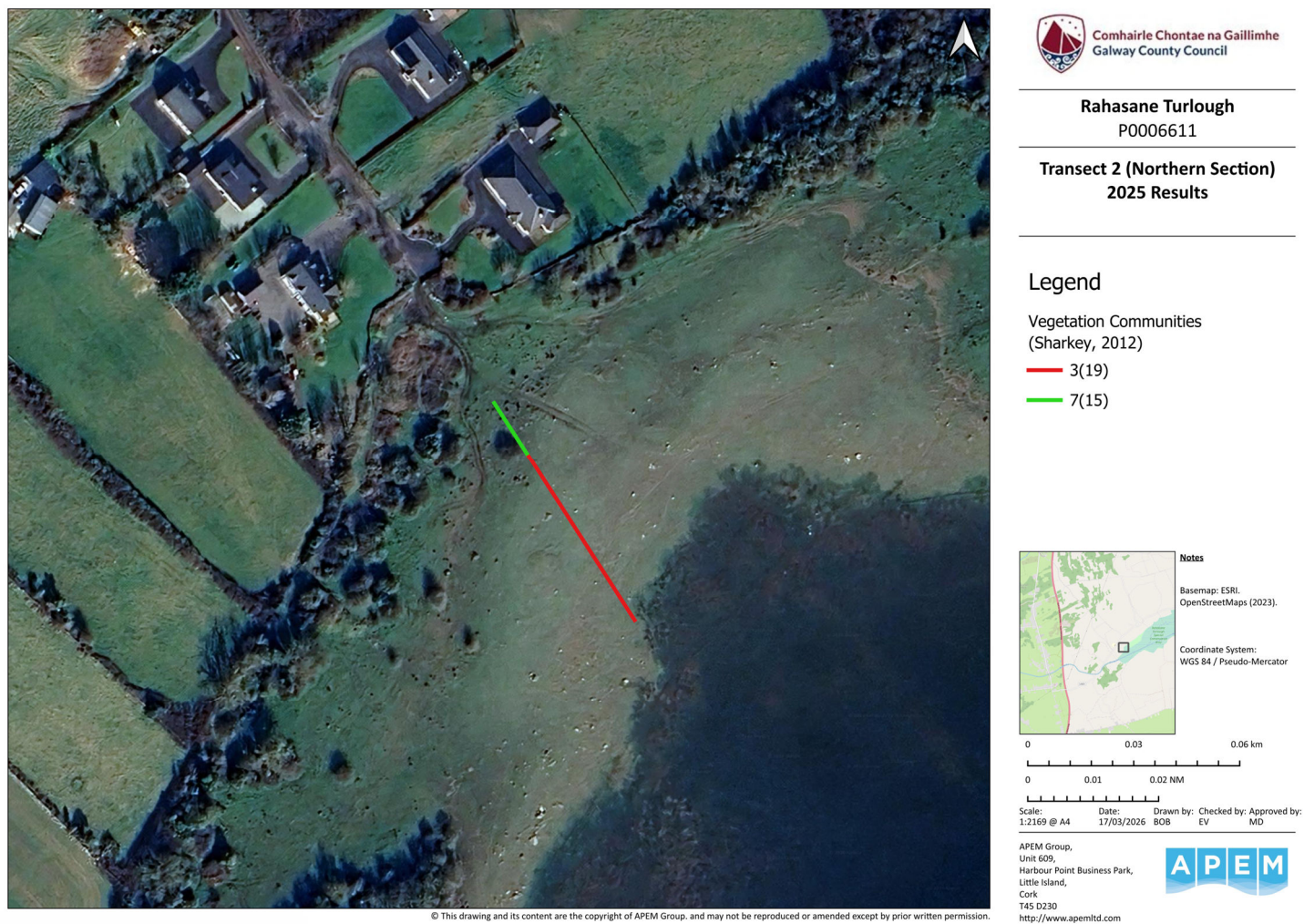


Figure D 1: Transect 2 northern section results 2025



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Galway County Council

Rahasane Turlough
P0006611

Transect 2 (Southern Section)
2025 Results

Legend

Vegetation Communities
(Sharkey, 2012)

1(10)

3(19)

3(3)

3(4)

Hedgerow

Scrub



Notes

Basemap: ESRI,
OpenStreetMaps (2023).

Coordinate System:
WGS 84 / Pseudo-Mercator

0 0.06 0.12 km

0 0.01 0.02 NM

Scale: 1:3765 @ A4 Date: 17/03/2026 Drawn by: BOB Checked by: EV Approved by: MD

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Cork
T45 D230
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Figure D 2. Transect 2 south section results 2025

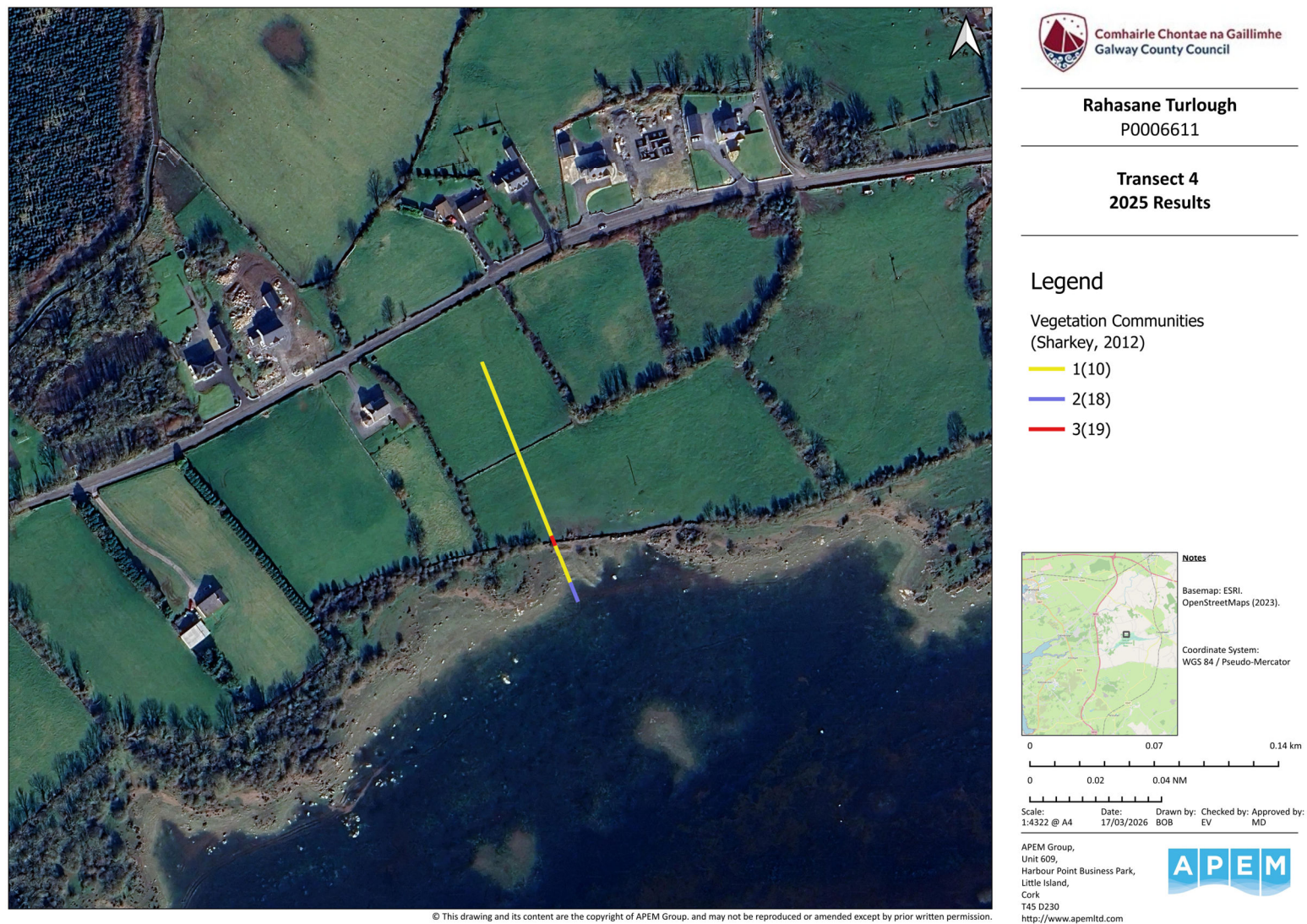


Figure D 3. Transect 4 results 2025

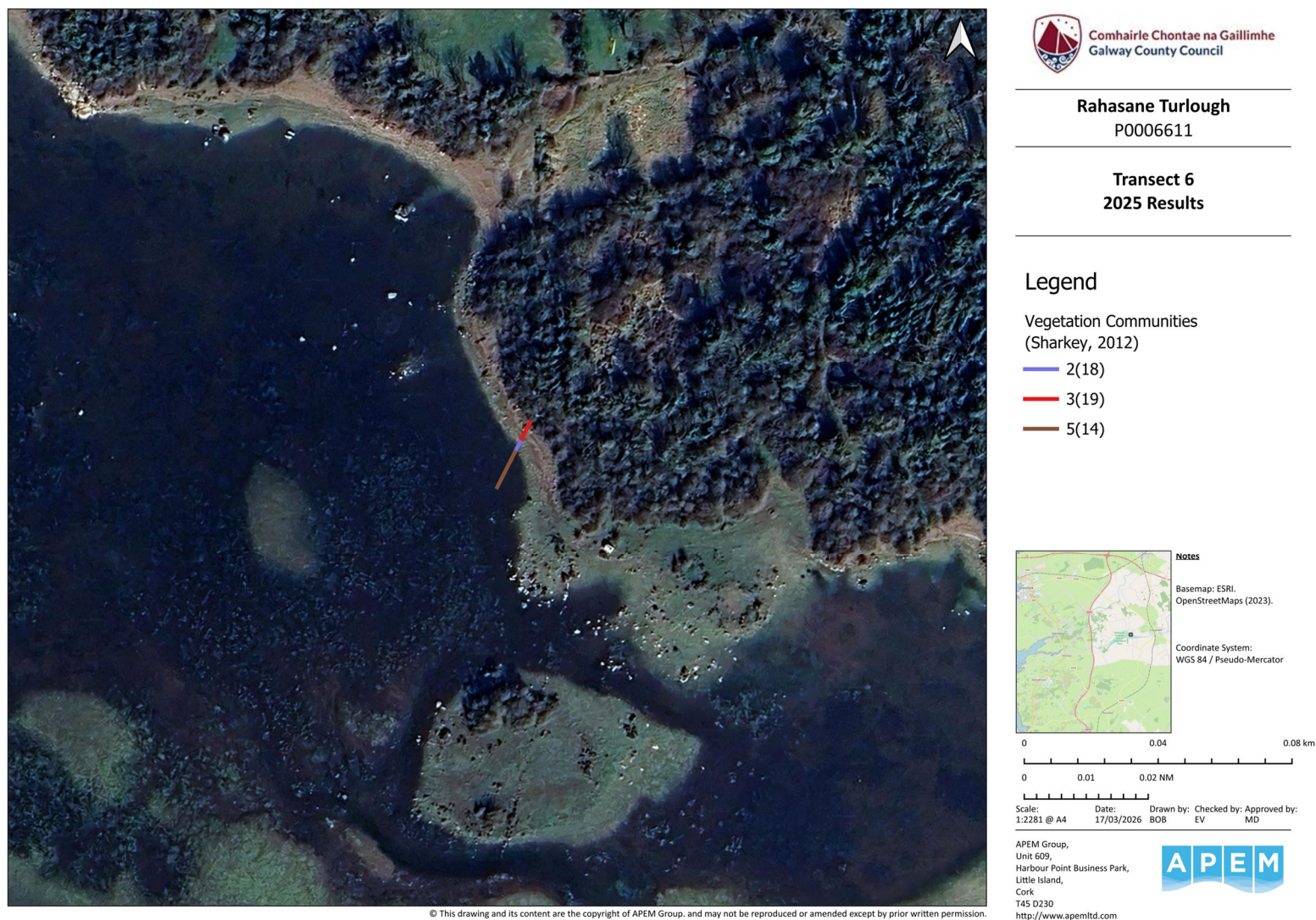


Figure D 4. Transect 6 results 2025

Appendix E: Vegetation Transect Comparison Results 2021-2025

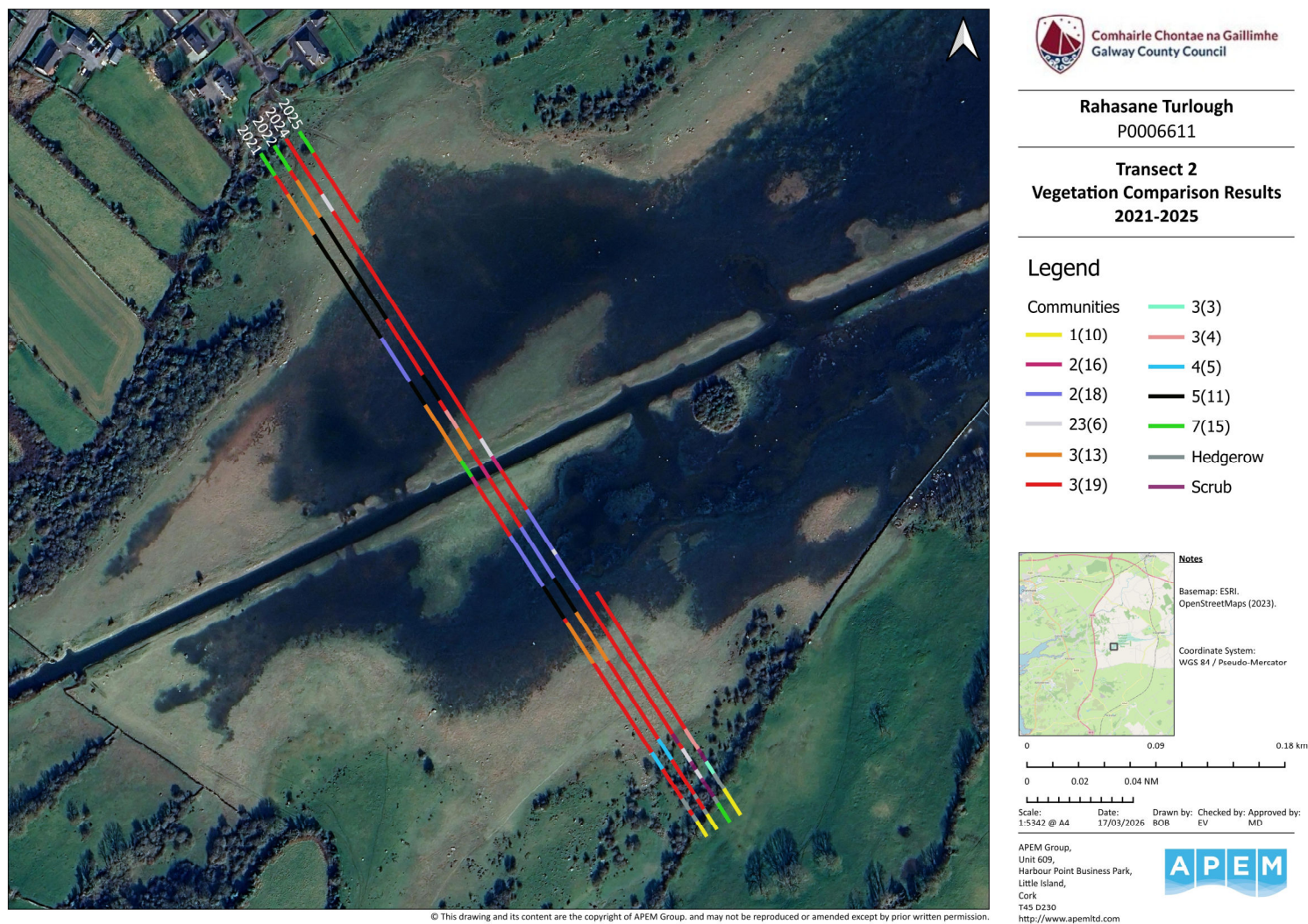


Figure E 1. Transect 2 results 2021 to 2025

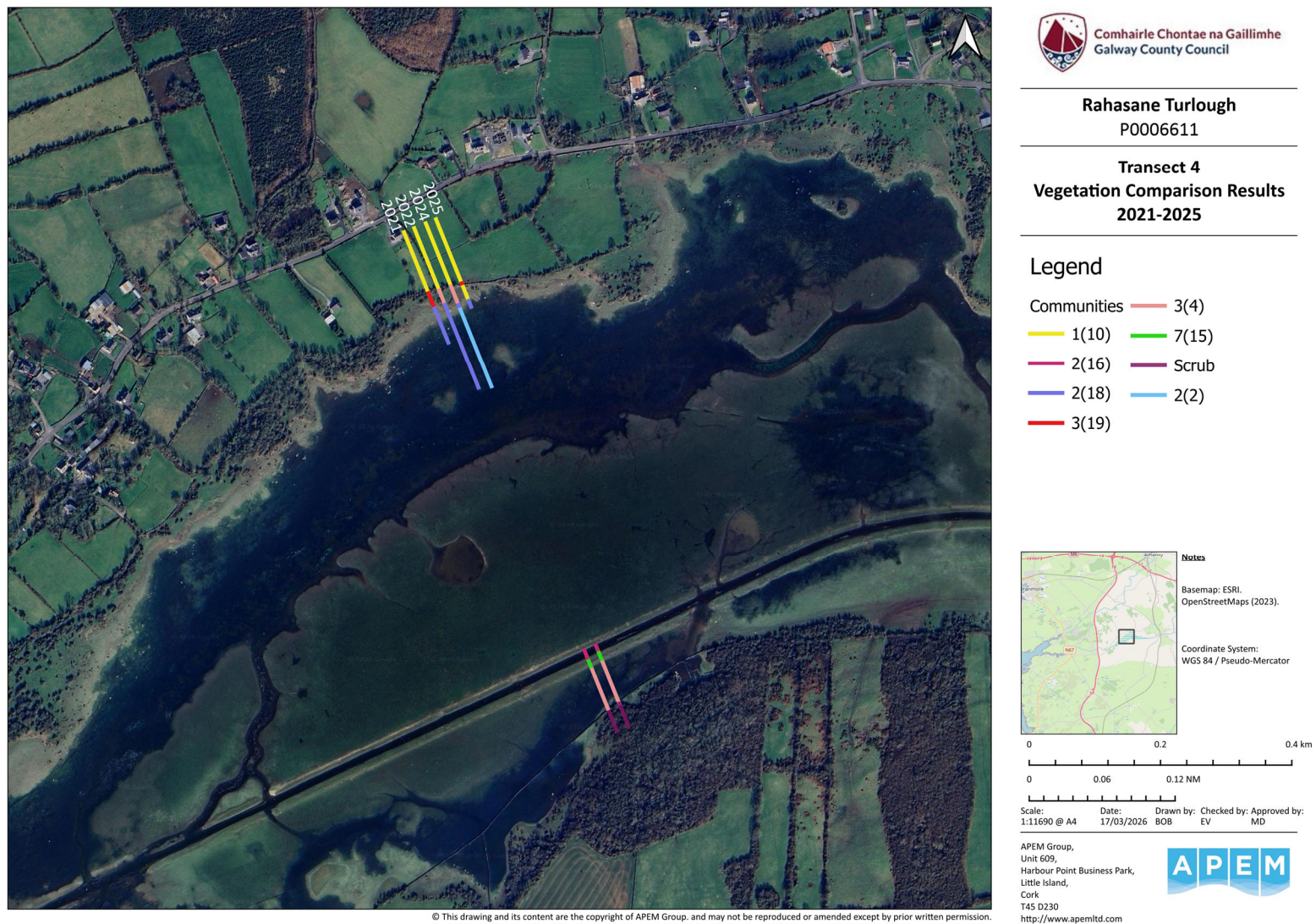


Figure E 2. Transect 4 results 2021 to 2025



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Figure E 3. Transect 6 results 2021 to 2025



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Galway County Council

Rahasane Turlough
P0006611

Transect 6
Vegetation Comparison Results
2021-2025

Legend

Communities	7(15)
2(16)	Hedgerow
2(18)	3A Tall herb
3(19)	5(14)
3(4)	



Notes

Basemap: ESRI,
OpenStreetMaps (2023).

Coordinate System:
WGS 84 / Pseudo-Mercator

0 0.09 0.18 km

0 0.02 0.04 NM

Scale: 1:5342 @ A4 Date: 17/03/2026 Drawn by: BOB Checked by: EV Approved by: MD

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Appendix F: Vegetation Comparison Tables 2021-2025

Table F 1: Summary of Transect 2 vegetation relevé results, Rahasane Turlough, 2021-2025.

Communities and species are colour-coded by typical favoured habitat as follows: yellow - usually terrestrial, blue - usually aquatic, grey – intermediate between aquatic and terrestrial. Darker grey cells show a species was not recorded in that relevé.

Transect 2	Relevé T2R2					Relevé T2R4					Relevé T2R6					Relevé T2R12					Relevé T2R16				
Date	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025
Species																									
<i>Achillea millefolium</i>		6	12		1																				
<i>Agrostis stolonifera</i>	60	23	5	10	50	40	40	40	50		50	33	25	25		55	65	52	35		35	38	20	10	70
<i>Alopecurus geniculatus</i>																2									
<i>Argentina anserina</i>	35	32	28	75	20	65	15	30	60		70	25	28	35			16	34	25		40	30	70	70	35
<i>Bellis perennis</i>	+	<4	5		<4						1	<1	2												
<i>Brachythecium rutabulum</i>							<4					<1					2					<4			
<i>Bryum</i> sp.							<1																		
<i>Calliergonella cuspidata</i>			1																<1						
<i>Cardamine pratensis</i>	+			<1	1		<1	1				<1	<1			3		<1			0.5	<4			4
<i>Carex hirta</i>	+										20														
<i>Carex nigra</i>	6	5	<1					5					3												
<i>Carex panicea</i>													2												
<i>Carex</i> sp.									1					5											
<i>Cerastium fontanum</i>					1						1	<1	<1	1										1	
<i>Cinclidotus fontinaloides</i>		<4	<1	<1	2						5														
<i>Cirsium arvense</i>	4					+																		1	
<i>Cirsium</i> sp.																							1		
<i>Equisetum arvense</i>									<1																

Transect 2	Relevé T2R2					Relevé T2R4					Relevé T2R6					Relevé T2R12					Relevé T2R16				
Date	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025
Species																									
<i>Festuca rubra</i>		<4											<1												
<i>Filipendula ulmaria</i>														<1											
<i>Fontinalis antipyretica</i>																		4							
<i>Galium palustre</i>						+	10	5	<1			5				3		<1	<1		1	<4	1	<1	<4
<i>Gnaphalium uliginosum</i>							<1											<1	<1						
<i>Hypochaeris radicata</i>																								1	
<i>Hydrocotyle vulgaris</i>		<4												1							<4				
<i>Juncus articulatus</i>						2																			
<i>Juncus</i> sp.												<1													
Leafy liverwort																								<1	
<i>Lolium perenne</i>			5		20																				
<i>Lotus corniculatus</i>				<1																					
<i>Lysimachia nummularia</i>																			1						
<i>Mentha aquatica</i>						3	5	2	<1							6	<4	4	<1						
<i>Moss (Kinderbergia sp.)</i>					1																				
<i>Myosotis scorpioides</i>				<1	1	10	10	10			+	2		<1		10	12	8	10		5	<4	<1	<1	2
<i>Nasturtium officinale</i>																	<4								
<i>Persicaria amphibia</i>							<4																		
<i>Persicaria minus</i>																					0.5				
<i>Plagiochila</i> sp.	+																								
<i>Plantago lanceolata</i>		<4	2		1							4	6	<1											
<i>Plantago major</i>	+		1	<1			2	4	<1		+					1					2		<1	<1	
<i>Poa annua</i>			15																						

Transect 2	Relevé T2R2					Relevé T2R4					Relevé T2R6					Relevé T2R12					Relevé T2R16				
Date	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025
Species																									
<i>Poa pratensis</i>								10																	
<i>Potentilla reptans</i>		4						2	1			<4	2	5								<4	<1	2	3
<i>Prunella vulgaris</i>							<1		<1										<1						
<i>Ranunculus repens</i>	10		1	1	<4	5	<4	3	<1		10	<1	<1	<1							15	<4	1	<1	5
<i>Ranunculus trichophyllus</i>																1									
<i>Rorippa</i> sp.							<1										<4								
<i>Rumex acetosa</i>					<4																				2
<i>Rumex crispus</i>	10	7	2	15	1		<4	1	1		5	1	2			0.5						<4		1	1
<i>Scorzoneroide autumnalis</i>	1	<4	<1								4	<4	<1	<1							15	<4	<1	<1	4
<i>Stellaria media</i>				1																			<1	1	1
<i>Taraxacum officinale</i>			1		<4																				2
<i>Trifolium repens</i>	30	18	70	20	23			5	2		15	30	28	10							30	26	20	10	1
<i>Urtica dioica</i>					1																				
<i>Viola stagnina</i>							<4																		
Species richness	13	13	16	11	17	8	16	13	12		12	15	13	13		9	7	8	9		10	12	10	13	15

Table F 2: Summary of Transect 4 vegetation relevé results, Rahasane Turlough, 2021-2025.

Communities and species are colour-coded by typical favoured habitat as follows: yellow - usually terrestrial, blue - usually aquatic, grey – intermediate between aquatic and terrestrial. Darker grey cells show a species was not recorded in that relevé.

Transect 4	Relevé T4R5					Relevé T4R10					Relevé T4R16					Relevé T4R18					Relevé T4R22				
Date	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025
Species																									
<i>Agrostis stolonifera</i>		25	28	35	50			50	10		75					50					90		30	30	
<i>Alopecurus geniculatus</i>																					1				
<i>Argentina anserina</i>	50	50	55	70	55				<1		5					15					7		23	50	
<i>Berula erecta</i>								2	1																
<i>Capsella bursa-pastoris</i>				<1																					
<i>Cardamine pratensis</i>					1			<1													3				
<i>Carex hirta</i>																							10		
<i>Carex nigra</i>																3									
<i>Carex</i> sp.																							10		
<i>Cerastium fontanum</i>		<1	1		<1																		1		
<i>Cinclidotus fontinaloides</i>		<1	1	<1																					
<i>Eleocharis palustris</i>							6	15																	
<i>Festuca rubra</i>	60					40																			
Filamentous green algae								<1	5																
<i>Fontinalis antipyretica</i>																					0.5				
<i>Galium palustre</i>				<1				<1	<1		5										3		1		
<i>Glyceria fluitans</i>								4	5																
Leafy liverwort																									
<i>Lolium perenne</i>					15																		<1		
<i>Mentha aquatica</i>					1			3	1		10												2		

Transect 4	Relevé T4R5					Relevé T4R10					Relevé T4R16					Relevé T4R18					Relevé T4R22				
Date	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025
Species																									
<i>Myosotis scorpioides</i>	+	5	1	<1	3	5		23	1		5										5		5	1	
<i>Persicaria amphibia</i>		<4			<1			15	50																
<i>Persicaria minus</i>																					1				
<i>Plantago lanceolata</i>																									
<i>Plantago major</i>		2		<1												15								<1	
<i>Poa annua</i>																								2	
<i>Potentilla reptans</i>	10	2	2	<4	5																		7	1	
<i>Ranunculus repens</i>	20	10	6	<3	2						5					5							1	<1	
<i>Rorippa</i> sp.																					2				
<i>Rumex acetosa</i>																5									
<i>Rumex crispus</i>	+	5	3	7	2																			1	
<i>Scorzoneroide autumnalis</i>	+		<1													5									
<i>Sphagnum cuspidatum</i>									10																
<i>Stellaria media</i>		<1		1												2									
<i>Trifolium repens</i>			4	<2	1											5									
<i>Viola stagnina</i>	+																								
Species richness	8	11	10	12	12	2		10	11		6					9					9		10	9	

Table F 2: Summary of Transect 6 vegetation relevé results, Rahasane Turlough, 2021-2025.

Communities and species are colour-coded by typical favoured habitat as follows: yellow - usually terrestrial, blue - usually aquatic, grey – intermediate between aquatic and terrestrial. Darker grey cells show a species was not recorded in that relevé.

Transect 6	Relevé T6R2					Relevé T6R6					Relevé T6R12					Relevé T6R16					Relevé T6R18				
Date	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025
Species																									
<i>Agrostis stolonifera</i>											15	50	20	22		10	48	43	50		20	20	22	40	
<i>Alopecurus geniculatus</i>												<4												1	
<i>Argentina anserina</i>											50	30	35	38		30	32	25	27		15		36	50	
<i>Bellis perennis</i>																						<1	1		
<i>Cardamine pratensis</i>						1						<1		<0			<4		<1			<1			
<i>Carex hirta</i>													<1												
<i>Carex nigra</i>												3	20	15		20	4	4			10		3		
<i>Carex</i> sp.														<4				5					1		
<i>Cerastium fontanum</i>																							1	<1	
<i>Cirsium</i> sp.																							<1		
<i>Festuca rubra</i>											15	<4					4	2					6		
<i>Filipendula ulmaria</i>																20		<1							
<i>Galium palustre</i>												<1	3	<4			<4	<1	<1		5	2	1		
<i>Glyceria fluitans</i>						50																			
<i>Juncus articulatus</i>																							2		
<i>Juncus bulbosus</i>																		1	<1					<1	
<i>Juncus</i> sp.													<1	<2											
<i>Lolium perenne</i>																							2		
<i>Lotus corniculatus</i>																			2						
<i>Myosotis scorpioides</i>						3					1	3	3	<4			<4	<1	<1						

Transect 6	Relevé T6R2					Relevé T6R6					Relevé T6R12					Relevé T6R16					Relevé T6R18				
Date	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025	2014-2015	2021	2022	2024	2025
Species																									
<i>Phleum pratense</i>																							2		
<i>Plantago major</i>																		<1					1	1	
<i>Poa annua</i>																								<1	
<i>Potentilla reptans</i>													<1	<1			<4	<1	<1			<1	2		
<i>Prunella vulgaris</i>																						<4	2		
<i>Ranunculus repens</i>											20	10	15	10		5		3	<1			<4	3	<1	
<i>Rumex acetosa</i>																						<1			
<i>Rumex crispus</i>					2							<4												<1	
<i>Scorzoneroide autumnalis</i>											+					5					5	2	<1		
<i>Sparganium erectum</i>						1																			
<i>Stellaria media</i>																					5				
<i>Taraxacum officinale</i> agg.													<1					<1							
<i>Trifolium repens</i>						1							3			10		20	3		45		25	3	
<i>Veronica catenata</i>						1																			
<i>Veronica chamaedrys</i>																	<4								
<i>Veronica serpyllifolia</i>																							<1		
Species richness						7					6	10	11	10		7	9	13	11		7	9	17	12	

Appendix G: Macroinvertebrate Sampling Locations 2021-2025

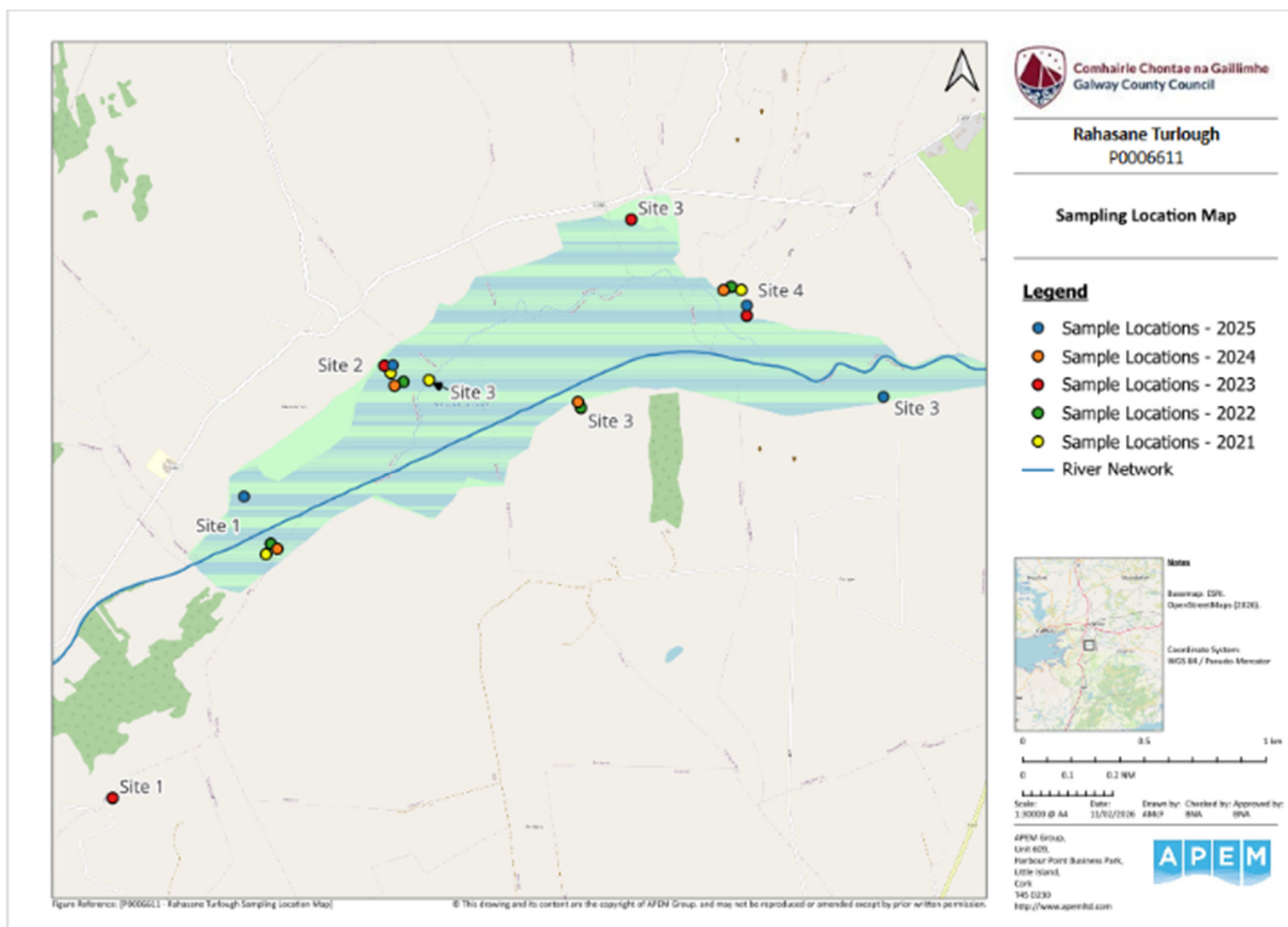


Figure G-1: Locations of sample sites surveyed for macroinvertebrate and PSYM analysis in 2021, 2022, 2023, 2024 and 2025

Appendix H: Aquatic Plant Taxa Lists

Figure H 1: Aquatic plant species recorded at the Rahasane Turlough 2021

Type of Macrophyte	Species	Rarity Score	Trophic Ranking Score	2021	2022	2024 No. of Sites present
Emergent Plants	<i>Agrostis stolonifera</i>	1	LP	X	X	4
	<i>Alisma plantago-aquatica</i>	1	LP	O	X	4
	<i>Apium nodiflorum</i>	1	10	O	O	1
	<i>Berula erecta</i>	2	10	X	X	2
	<i>Caltha palustris</i>	1	7	O	O	1
	<i>Cardamine pretensis</i>	1		O	X	2
	<i>Carex nigra</i>	1	5	O	X	0
	<i>Eleocharis palustris</i>	1	LP	O	O	3
	<i>Equisetum fluviatile</i>	1	LP	O	O	2
	<i>Equisetum palustre</i>	1		O	X	0
	<i>Filipendula ulmaria</i>	1		O	X	0
	<i>Galium palustre</i>	1		O	X	2
	<i>Geum rivale</i>	1		O	X	0
	<i>Glyceria fluitans</i>	1	LP	X	X	2
	<i>Hydrocotyle vulgaris</i>	1	LP	O	O	1
	<i>Juncus acutiflorus</i>	1		O	X	0
	<i>Juncus bulbosus</i>	1	5.3	O	X	1
	<i>Lythrum salicaria</i>	1		X	X	0
	<i>Mentha aquatica</i>	1	7.3	X	X	3
	<i>Myosotis scorpiodes</i>	1	9	X	X	4
	<i>Oenanthe fluviatilis</i>	2		O	X	0
	<i>Persicaria hydropiper</i>	1	10	O	O	1
	<i>Phalaris arundinacea</i>	1	8.5	X	X	2
	<i>Potentilla erecta</i>	1		O	X	0
	<i>Potentilla palustris</i>	1	5.3	O	X	0
	<i>Ranunculus flammula</i>	1	LP	O	X	1
	<i>Ranunculus reptans</i>	32		O	X	0
	<i>Ranunculus sceleratus</i>	1	10	O	X	0
	<i>Rorippa islandica</i>	8		O	X	2
	<i>Rorippa nasturtium-aquaticum</i>	1	10	O	O	A
	<i>Schoenoplectus lacustris</i>	2	7.7	X	O	
	<i>Solanum dulcamara</i>	1	10	O	O	2
	<i>Sparganium erectum</i>	1	8.5	O	X	2
	<i>Stellaria palustris</i>	2		O	X	0
	<i>Stellaria uliginosa</i>	1		O	X	0
	<i>Typha latifolia</i>	1	8.5	X	X	0
	<i>Typha angustifolia</i>	2	10	O	O	1

Type of Macrophyte	Species	Rarity Score	Trophic Ranking Score	2021	2022	2024 No. of Sites present
	<i>Veronica</i> sp. (undetermined)	1		O	X	1
	<i>Veronica beccabunga</i>	1	10	O	X	0
	<i>Veronica catenata</i>	2		O	X	0
Floating Leaved Plants	<i>Lemna</i> sp. (undetermined)	1		X	O	0
	<i>Lemna trisulca</i>	1	10	O	X	2
	<i>Nuphar lutea</i>	2	8.5	X	X	1
	<i>Persicaria amphibia</i>	1	9	O	X	3
	<i>Potamogeton natans</i>	1	LP	X	X	4
Submerged Plants	<i>Apium inundatum</i>	2	6.3	O	X	3
	<i>Callitriche</i> sp (undetermined)	1		X	X	4
	<i>Chara</i> sp.	2	7.3	X	X	3
	<i>Elodea canadensis</i> or <i>E. nuttallii</i>	1	8.65	X	X	2
	<i>Fontinalis antipyretica</i>	1	6.3	O	X	0
	<i>Hippuris vulgaris</i>	2	7.7	X	X	4
	<i>Myriophyllum spicatum</i>	2	9	X	O	0
	<i>Myriophyllum verticillatum</i>	4		O	X	2
	<i>Najas flexilis</i>	4		X	O	
	<i>Oenanthe fluviatilis</i>	2		O	O	1
	<i>Potamogeton lucens</i>	2	10	X	O	0
	<i>Potamogeton pusillus</i>	2	9	O	X	3
	<i>Ranunculus aquatilis</i>	2	10	X	X	0
	<i>Ranunculus circinatus</i>	2	10	O	X	0
	<i>Ranunculus trichophyllus</i>	2	8.5	X	X	0
	<i>Sparganium angustifolium</i>	2	3	X	X	0
	<i>Sparganium emersum</i>	1	10	X	X	3
	<i>Utricularia</i> sp (undetermined)	2		X	O	0
	<i>Utricularia vulgaris</i>	2	5	O	X	0
Total Number of PSYM Species				24	49	37

LP= Species exhibiting little nutrient preference

Appendix I: Macroinvertebrate metrics

Q Value Assessment

The EPA Q value classification is assigned based on the assessment of the macroinvertebrate sample, which involves recording the taxa present at a suitable and attainable (under field conditions) taxonomic resolution and their categorical relative abundance determined using approximate counts (as described in Feeley *et al.*, 2020). From this, the number of taxa present and categorical relative abundance of sensitive (Group A), less sensitive (Group B), tolerant (Group C), very tolerant (Group D) and most tolerant (Group E) taxa to organic pollution is examined. Additional Qualifying Criteria are also considered, consisting of recording the abundance of *Cladophora* spp, Macrophytes, and slime growths / sewage fungus, as well as the Dissolved Oxygen Saturation % and the level of substratum siltation. Then, based on the combination of number of taxa and relative abundance of the sensitive or tolerant groups present a Q value is assigned. Details on the assignment of the scores can be found in Toner *et al.*, (2005).

BMWP and ASPT

The Biological Monitoring Working Party (BMWP) index was designed to identify the degree of organic pollution based on the natural sensitivity of taxon to the pollution. Aquatic organisms respond to chemical changes in water, in particular, to the changes in dissolved oxygen concentrations. As pollution levels increase, the microbial oxygen demand rises, resulting in a decline in available oxygen concentrations. Many stream organisms require high dissolved oxygen concentration and are therefore not found in water bodies with lower oxygen concentrations. Macroinvertebrate families which are sensitive to pollution are assigned high BMWP scores, while pollution-tolerant taxa score low. In the BMWP system, benthic invertebrate taxa are assigned a score between 1 (tolerant to organic pollution) and 10 (intolerant to organic pollution). The BMWP score is the sum of the values for all families present in the sample. The number of BMWP-scoring families is typically recorded alongside the BMWP score, as is the Average Score Per Taxon (ASPT), which can be determined by dividing the BMWP score by the number of scoring taxa present. The BMWP score may vary significantly depending on whether the sampling process captures species found in some habitats but not in others. Standardisation of the BMWP score is therefore provided by the ASPT, with the average BMWP score per taxon allowing robust comparisons among sites.

BMWP was designed for assessing river quality but has been successfully incorporated into the PSYM method for pond quality assessment.

WHPT and WHPT-ASPT

The Whalley Hawkes Paisley Trigg (WHPT) metric is used in the UK for monitoring, assessing and classifying rivers in accordance with the requirements of WFD based on assessing the ecological quality of the macroinvertebrates present when sampled. It is a revised version of the original BMWP index. Empirical data was used in the development of the WHPT index to assign abundance related sensitivity weights to taxa. The taxa included in the index are modified from those used for the BMWP index and several taxa were removed due to insufficient data; some additional families were included where sufficient data were available, and some existing BMWP composite taxa were split into their constituent families. The WHPT-ASPT values typically range from 1 (indicative of sites with high organic matter concentration, typically associated in rivers with pollution and degradation) to 13 (indicative of sites with very low organic matter concentration, associated in rivers and lakes with low pollution and degradation). The WHPT-ASPT score standardises the WHPT score to an average per taxa to allow a robust comparison among sites.