

Septic Tank Replacement Phosphorus Mitigation Scheme – Technical Note

1. Introduction

Owing to the problems associated with elevated phosphorus (P) concentrations in the River Dee Special Area of Conservation (SAC), Local Planning Authorities (LPAs) within the Welsh Dee catchment now require planning applications to consider the potential impact new development may have on P inputs to the river. Gower Homes have development sites in the Dee catchment which may result in an increase in P inputs to the river. If a Gower Homes development will result in an increase in P inputs to the River Dee, an appropriate P mitigation solution may be needed in order to show that the additional P from the development will be 'neutralised', showing that the development is nutrient neutral and compliant with the Habitat Regulations.

As a potential mitigation solution to offset P inputs to the River Dee from their developments, Gower Homes are proposing to replace existing septic tank systems that currently discharge high levels of P to the Dee SAC. Old septic tanks are known to be sources of P pollution to river systems (O'keeffe et al., 2015), whereas new package treatment plants (PTPs) have been designed to achieve a greater standard of P removal. Thus, replacing old septic tanks with new PTPs that have certified P removal capabilities can provide a means of securing P mitigation. This Technical Note provides details of a proposed septic tank replacement scheme that has the potential to generate P mitigation that can be used by Gower Homes to deliver nutrient neutral development.

Section 2 of this note provides an overview of the potential impact that P loading may have on the Dee SAC and how this links to mitigation solutions. A quantification of the P mitigation that could be delivered by the solution and the maintenance and monitoring needed to secure the solution is provided in Section 3, with a summary of this note in Section 4.

2. Potential impacts from additional phosphorus inputs to the River Dee Special Area of Conservation

Excess P inputs to rivers can result in a process called eutrophication whereby algal blooms cause a linked set of environmental processes that harm aquatic ecosystems (Miller et al., 2014). Rivers that are designated as conservation sites under the Conservation of Habitats and Species Regulations 2017 (the Habitat Regulations), such as the River Dee SAC, have targets for P concentrations that are designed to reduce the risk of eutrophication. Meeting these targets will help to reduce deleterious effects on the ecological features which the site is designated

for. Recently, Natural Resources Wales (NRW) published a compliance assessment showing that many of the SAC rivers in Wales, including the Dee, are failing to meet their P targets (Hatton-Ellis and Jones, 2021).

In 2019, a ruling in the Court of Justice of the European Union (CJEU), the “Dutch nitrogen case” (Joined Cases C-293/17 and C-294/17), changed the way in which the Habitat Regulations were interpreted. This ruling has reduced the scope for authorising new development where a development will increase P loading to a SAC river which is failing its P targets. As a consequence of the SAC rivers compliance assessment (Hatton-Ellis and Jones, 2021), NRW have issued planning advice stating that new development in the catchment of a SAC river that is failing its P targets, e.g. the River Dee SAC, will need to show that it will not increase P inputs to the river in a manner that hampers the SAC reaching its P target¹. Where a development will increase P inputs to a SAC river that is failing its P targets and the increased P input will be via a wastewater treatment works not assessed to have permit headroom to allow connections from new development, it will not be possible to conclude no Adverse Effects on Integrity (AEoI) of the SAC through a Habitat Regulations Assessment (HRA) and the development will need to show how it will mitigate its P input to remove the risk of AEoI.

In order to show that a mitigation solution will remove the risk of AEoI from P inputs to the Dee SAC, the solution should pass the following key tests:

- Use best available evidence to inform how it will remove P loading to the Dee SAC.
- Be achievable beyond reasonable scientific doubt.
- Apply the Precautionary Principle where uncertainty arises.
- Be maintained for the lifetime of a development.

To pass these tests, a mitigation solution should be evidenced as being guaranteed, effective, reliable and timely.

3. Quantifying phosphorus mitigation from the proposed mitigation scheme

The proposed mitigation scheme will replace a septic tank serving two existing properties near Overton Bridge, Erbistock, in the Wrexham LPA area. The septic tank that currently serves the properties discharges to ground ~40 m from the banks of the River Dee. Where the tank discharges, the ground is visibly saturated, with treated effluent from the discharge flowing into the Dee via a mix of shallow throughflow and surface runoff. Due to a low level of infiltration and the short distance between the effluent discharge point and the river, there is limited potential for P attenuation through sorption of P to soils and sediments. This

¹ See NRW planning advice at: <https://naturalresources.wales/guidance-and-advice/business-sectors/planning-and-development/our-role-in-planning-and-development/advice-to-planning-authorities-for-planning-applications-affecting-phosphorus-sensitive-river-special-areas-of-conservation/?lang=en>, accessed on 26/03/2023.

suggests that the current septic tank is a source of P to the River Dee and that replacing it with a more efficient PTP would reduce P inputs to the river, thus providing mitigation. The following sub-sections provide a quantification of the amount of mitigation this solution could provide and the suggested maintenance and monitoring requirements to secure the mitigation solution.

3.1 Quantification of P mitigation

3.1.1 Overview of the approach and required inputs

Quantifying the potential P mitigation that could be delivered by the septic tank replacement scheme followed the approaches to calculating P loads from wastewater detailed in the Dee Catchment Phosphorus Reduction Strategy (DTA Ecology, 2021), supporting guidance on P budget calculations in Carmarthenshire (Ricardo EE, 2022), and P budget calculation methodologies used in England. For the purposes of calculating mitigation, P loading from wastewater is expressed in kg total phosphorus (TP) per year (kg TP/year).

The mitigation that the scheme may deliver is calculated as the balance between the P load that is discharging from the existing septic tank and the P load that will be discharged following an upgrade to a PTP.

To calculate the P load coming from the septic tank prior to replacement and the P load that will come from the new PTP post-replacement, the concentration of TP in the discharge from both systems is multiplied by the discharge rate.

An estimate of the discharge rate from a septic tank or PTP can be obtained by following NRW guidance (NRW, 2017), using the following inputs:

1. Number of people occupying a property.
2. Average daily water use per person.

The concentration of P in the effluent from a septic tank or PTP is ideally taken from certified water quality testing of the system or from peer reviewed literature in lieu of certified test results.

3.1.2 Calculation of mitigation from the proposed septic tank replacement scheme

Table 1 show the calculations used to obtain an estimate of the discharge rate from an onsite sewage treatment system at the proposed mitigation scheme location. These calculations can be applied to both the existing septic tank and the proposed replacement PTP and follow guidance on small sewage effluent discharges (NRW, 2017).

Table 1: Calculation of the daily discharge rate from an onsite sewage treatment system at the proposed mitigation scheme location.

Input	Calculation / input	Description
Number of houses connecting to onsite treatment system	2	NA
Number of people occupying the houses (P_e)	$3 \times 2 = 6$	One six- and one four-bedroom house using a conservative average occupancy of 3 people per house. This is a precautionary occupancy estimate that is over half the value recommended in NRW (2017) and is closer to the average occupancy value of 2.4 for new developments suggested in the DCPRS (DTA Ecology, 2021).
Average water usage per person (f)	150 L/day	The average UK water usage per person stated by Dwr Cymru Welsh Water (DCWW) ² and NRW (2017).
Combine P_e and f to get the daily discharge rate from the onsite sewage treatment system	$P_e \times f = 6 \times 150$ L/day = 900 L/day Converting to m^3 /day $900 \text{ L/day} / 1000 = 0.9$ m^3 /day	The daily water use and thus discharge rate from an onsite sewage treatment system at the proposed mitigation site location.

To calculate the TP load from the existing septic tank system and the proposed replacement PTP, the discharge rate shown in Table 1 is multiplied by the concentration of TP in effluent from the onsite sewage treatment system. Septic tanks generally do not have P removal capabilities and have been reported as notable sources of P and other types of pollution to rivers, with studies often reporting high P concentrations in their effluents (e.g. Richards et al., 2016). Where the concentration of P from a septic tank is not known, values can be taken from the literature on septic tanks and nutrient pollution. Carmarthenshire's nutrient budget calculator uses a default value of 11.6 mg TP/L for the effluent from septic tanks that do not have effluent TP concentrations specified and certified by the manufacturer (Ricardo EE, 2022). This value is taken from a review of P in septic tank effluent by O'keeffe et al. (2015). This study is considered the best available

² See DCWW information on water efficiency at: <https://corporate.dwrcymru.com/en/community/education/teaching-resources/secondary-resources/water-efficiency>, accessed on 10/01/2023

evidence on TP concentrations in septic tank effluent as it compiles outputs from multiple studies from which an average was taken. Other recent reviews also detail findings that show similar concentrations of P reported in studies of septic tank effluent (Lusk et al., 2017; Robertson et al., 2019). As there is no monitoring data available for the effluent discharge at the proposed mitigation site location, the default concentration of 11.6 mg TP/L was used to estimate the current P load from the existing septic tank.

Using the default septic tank effluent TP concentration, the annual P load from the septic tank at the proposed mitigation scheme location can be calculated as follows:

- Calculate daily TP load in mg/day: $0.6 \text{ m}^3/\text{day} \times 1000 \times 11.6 \text{ mg TP/L} = 10,440 \text{ mg TP/day}$
- Convert the daily load in mg to kg: $10,440 \text{ mg TP/day} / 1,000,000 = 0.01 \text{ kg TP/day}$
- Convert the daily load in kg to an annual load: $0.01 \text{ mg TP/day} \times 365.25 = \mathbf{3.8 \text{ kg TP/year}}$

The TP concentration in the effluent from the existing septic tank at the proposed mitigation scheme location is likely to be considerably higher than the TP concentration in the proposed replacement PTP. Thus, a replacement PTP that achieves a lower certified TP concentration in its effluent will result in a reduction in TP loading to the River Dee, providing P mitigation that can be used to offset other developments in areas of the Dee catchment that are downstream of the septic tank replacement location.

The proposed mitigation scheme will replace the existing septic tank with a Graf One2Clean PTP. This system has a certified TP concentration in its final effluent of 1.6 mg/l (see Appendix 1 for the Graf One2Clean testing certificate). The P load output from the new PTP can thus be calculated as follows:

- Calculate daily TP load in mg/day: $0.9 \text{ m}^3/\text{day} \times 1000 \times 1.6 \text{ mg TP/L} = 1,440 \text{ mg TP/day}$
- Convert the daily load in mg to kg: $1,440 \text{ mg TP/day} / 1,000,000 = 0.001 \text{ kg TP/day}$
- Convert the daily load in kg to an annual load: $0.001 \text{ mg TP/day} \times 365.25 = \mathbf{0.5 \text{ kg TP/year}}$
- Calculate the balance between the current estimated TP load from the existing septic tank and the proposed new PTP: $3.8 \text{ kg TP/year} - 0.5 \text{ kg TP/year} = 3.3 \text{ kg TP/year}$

Based on the above calculations, it has been shown that the replacement PTP will reduce P loading to the River Dee SAC, providing 3.3 kg TP/year of mitigation that can be used to offset new development.

3.1.3 Linking P offsets to new housing

The above assessment provides a calculation of the potential offset that could be delivered by a proposed PTP replacement scheme at Overton Bridge. In order to link the proposed mitigation scheme to new housing, it is necessary to calculate the amount of P that will be generated by a new housing development. This can be done using the same nutrient budget approach used above to calculate the mitigation potential from the proposed scheme, where the additional P load from a new development is calculated as a function of water use and the P concentration in discharge from a wastewater treatment works (WwTW). Table 2 shows the calculation of water use from a single new dwelling.

Table 2: Calculation of the additional wastewater volume to be discharged via foul drainage from a single dwelling at a new development site.

Input	Calculation / input	Description
Number of people occupying the houses (P_e)	2.4	The average occupancy value for new housing suggested in the DCPRS (DTA Ecology, 2021). This value is slightly more precautionary than the Welsh national average of 2.3 recommended in the Carmarthenshire Nutrient Budget Calculator (Ricardo EE, 2022)
Average water usage per person (f)	120 L/day	Daily water usage in a new property, which is secured due to the requirements of the Building Regulations for water efficiency measures to secure daily water use of 110 L/person/day and has a precautionary allowance of an extra 10 L/person/day
Combine P_e and f to get the daily discharge rate a new dwelling	$P_e \times f = 2.4 \times 120$ L/day = 288 L/day Converting to m^3 /day $288 \text{ L/day} / 1000 = 0.29$ m^3 /day	The daily water use and foul drainage discharge rate from a single new dwelling.

Using the same calculations detailed in Section 3.1.2, the daily water use per dwelling can be combined with the concentration of P in final effluent from a WwTW to obtain an estimate of the additional P load output by a new dwelling. This is the P load per dwelling that requires mitigation. Dwr Cymru Welsh Water (DCWW) recently released data providing the P permit concentrations for WWTWs

in the Dee catchment³. These P permits describe the final effluent P concentrations that are needed to complete the P load calculations for new dwellings. At present, permit limited WwTWs in the Dee catchment have one of two P permit concentrations. Table 3 shows the amount of mitigation required for a house connecting into a WwTW with either of these P permits. For reference, the P mitigation values in Table 3 were calculated using following equation, which condenses the calculation steps shown in Section 3.1.2:

$$\frac{P_c}{10^6} \times 0.29 \text{ m}^3/\text{day} \times 1000 \times 365 \text{ days}$$

Where P_c is the P permit concentration for a given WwTW as shown in Table 3 and $0.29 \text{ m}^3/\text{day}$ is the daily water use per dwelling shown in Table 2.

Table 3: Required P mitigation per new dwelling for the two P permit concentrations currently in place at WwTWs in the Dee catchment.

P permit concentration (mg TP/l)	P mitigation required per dwelling (kg TP/year)
1	0.1
2	0.2

Table 3 indicates that the proposed mitigation scheme, which will generate 3.3 kg TP/year of mitigation, could mitigate for 33 new dwellings where a development is connecting to a WwTW with a P permit of 1 mg TP/L and 15 new dwellings where a development is connecting into a WwTW with a P permit of 2 mg TP/L. It should be noted that this does not account for the impact of land use change on P budgets, which may slightly increase or decrease the number of new dwellings the scheme can mitigate, depending on the type of pre- and post-development land use.

3.2 Maintenance and monitoring of the proposed mitigation solution

PTPs require regular maintenance in order to continue functioning as designed, which will in turn help to continue providing the same level of P treatment for raw sewage entering the treatment system. As recommended in the NRW guidance on the registration of small sewage effluent discharges (NRW, 2017), the proposed PTP will be operated and maintained in line with the manufacturer's guidance. A maintenance plan will be devised and enacted, with records of maintenance and de-sludging of the PTP kept for 5 years, in line with the requirements in Welsh Government Circular 008/2018.

De-sludging of the PTP will be required at the intervals specified in the Graf One2Clean user guidance. A representative for Graf UK has indicated that

³ Data were made available via: <https://corporate.dwrcymru.com/en/community/environment/river-water-quality/sac-rivers>, accessed on: 03/04/2023

maintenance is needed annually to de-sludge the system. A full service of the unit is recommended at 5-year intervals.

As part of the maintenance plan, it is also recommended to include water quality monitoring to check that the PTP continues to treat effluent to a TP concentration of 1.6 mg TP/L. Water quality samples can be taken at the time of annual servicing, with remedial action taken to fix problems with P removal in the PTP should the water quality sampling show the PTP is not performing to its certified P removal standard. Records of water quality sampling are recommended to be retained for 5 years. The maintenance and monitoring plan should provide the required certainty that the PTP will continue delivering mitigation for the Development in perpetuity.

4. Summary

The River Dee SAC is failing to meet its conservation targets for P, with concomitant impacts on protected habitats within the river. Following a landmark ruling in the CJEU, the 'Dutch Nitrogen case', NRW issued planning advice that requires new development to assess whether it will result in an increase in P loading to Welsh SAC rivers such as the Dee that are failing their P targets. Where a development will result in an increase in P loading to the River Dee SAC, this additional P load will require mitigation.

This technical note has presented a quantification of the mitigation that can be delivered from a proposed septic tank replacement scheme within the Dee catchment. The P mitigation potential of the scheme has been quantified following approaches to calculating wastewater nutrient loads applied in nutrient budget calculation approaches. Inputs to the calculations were derived based on NRW guidance and P concentrations taken from certified testing results, and from peer reviewed literature. These inputs are considered to be the best available evidence and combined they show the scheme will provide P mitigation beyond reasonable scientific doubt. Where appropriate, the Precautionary Principle was applied in the selection of input values.

The output from the calculation of mitigation potential from the proposed scheme shows it will generate mitigation of 3.3 kg TP/year. The scheme thus has the potential to mitigate between 15 and 33 new dwellings, depending on the P permit at the WWTW that a new development will connect to. To secure this mitigation in perpetuity, recommendations for a maintenance and monitoring plan have been provided. A maintenance and monitoring plan will help to ensure the replacement PTP keeps functioning as designed and continues to provide P mitigation. This plan will be formerly produced and enacted by the owner and operator of the PTP, in line with manufacturer and Welsh Government guidance.

5. References

DTA Ecology, 2021. The Dee Catchment Phosphorus Reduction Strategy.

Hatton-Ellis, T., Jones, T., 2021. Compliance Assessment of Welsh River SACs against Phosphorus Targets.

Lusk, M.G., Toor, G.S., Yang, Y.Y., Mechtensimer, S., De, M., Obreza, T.A., 2017. A review of the fate and transport of nitrogen, phosphorus, pathogens, and trace organic chemicals in septic systems. *Crit Rev Environ Sci Technol* 47, 455–541.

Miller, C., Magdalina, A., Willows, R.I., Bowman, A.W., Scott, E.M., Lee, D., Burgess, C., Pope, L., Pannullo, F., Haggarty, R., 2014. Spatiotemporal statistical modelling of long-term change in river nutrient concentrations in England & Wales. *Science of the Total Environment* 466–467, 914–923.

NRW, 2017. Guidance for the registration of small sewage effluent discharges.

O’keeffe, J., Akunna, J., Olszewska, J., Bruce, A., May, L., Allan, R., 2015. Practical measures for reducing phosphorus and faecal microbial loads from onsite wastewater treatment system discharges to the environment: a review.

Ricardo EE, 2022. Nutrient Budget Calculator Guidance: A guide on how to calculate a phosphorus budget for a development.

Richards, S., Paterson, E., Withers, P.J.A., Stutter, M., 2016. Septic tank discharges as multi-pollutant hotspots in catchments. *Science of the Total Environment* 542, 854–863.

Robertson, W.D., Van Stempvoort, D.R., Schiff, S.L., 2019. Review of phosphorus attenuation in groundwater plumes from 24 septic systems. *Science of the Total Environment* 692, 640–652.

Version control

Version number	Produced by	Role	Date
V1	Dr Gabriel Connor-Streich	Director and Principal Environmental Scientist	27/03/2023
V2	Dr Gabriel Connor-Streich	Director and Principal Environmental Scientist	03/04/2023
V3 – Final	Dr Gabriel Connor-Streich	Director and Principal Environmental Scientist	06/04/2023

Appendices

Appendix 1

The Graf One2Clean Package Treatment Plant testing certificate is provided as a separate PDF.