Herefordshire Council Interim Phosphate Delivery Plan

Stage 2 – Mitigation Options for Phosphate Removal Non-Technical Summary

1. The Need for Phosphate Mitigation to Support Nutrient Neutral Development

Stage 1 of the Interim Phosphate Delivery Plan provides a methodology for calculating phosphate budgets for new residential developments. The output of a phosphate budget is an annual amount of phosphate that will be produced by a new residential development. This annual amount of phosphate needs to be mitigated, i.e. removed from the environment within the catchment of the River Wye Special Area of Conservation (SAC). Mitigation of the phosphate produced by the new development will allow the development to be "nutrient neutral" and subsequently to comply with the Habitat Regulations through a Habitat Regulations Assessment (HRA). Stage 2 of the Interim Phosphate Delivery Plan provides a review of the potential mitigation solutions that could be used remove phosphate from the environment in the River Wye SAC catchment. The outcome of this review is a set of recommendations for options that are likely to provide robust solutions for phosphate mitigation to achieve nutrient neutral residential development.

2. The Approach to the Mitigation Options Review

The review of phosphate mitigation solutions used a critical analysis of academic literature and industry best practice guidance to assess the viability of different mitigation solutions. There are four key tests of HRA compliance for any mitigation solution and these tests were used to frame the analysis of the viability of each mitigation solution. These four key tests are:

1. The scale of phosphorous reductions that can be achieved by a mitigation solution are based on *best available evidence*.

2. The available evidence for a mitigation solution suggests *beyond reasonable scientific doubt* that the solution will be effective.

3. The estimates for phosphorous reductions suggested for the scheme are *precautionary*, in line with the Precautionary Principle.

4. The reductions in phosphorous loading can be secured *in perpetuity* which, for the purposes of a housing development is considered to be 80-125 years.

Mitigation solutions that fail any of these tests suggest that the mitigation solution will not be able to reliably mitigate phosphate inputs to the River Wye SAC and therefore cannot be used to achieve nutrient neutrality. If a development cannot prove it will be nutrient neutral, it will not be compliant with an HRA and thus it is very difficult to grant planning permission.

The review began with a long list of mitigation solutions. The theoretical potential of these solutions was screened against the HRA tests and also considered with respect to the feasibility of the solution within the River Wye SAC catchment. This screening process reduced the long list to a shortlist, which was subjected to a more detailed analysis of the evidence base to support the solution, again in the context of the HRA tests. The short-listed solutions were:

- Water efficiency measures – reduction in household water usage and associated phosphorus export in wastewater from a new development
- Onsite wastewater treatment using package treatment plants – removal of phosphorous from wastewater
- Sustainable Drainage Systems (SuDS) – using green drainage infrastructure to remove phosphorous from urban runoff
- Wetland creation – vegetated waterbodies and non-vegetated ponds that retain phosphorous
- Agricultural land abandonment and woodland planting – reduction in phosphorous inputs and exports from farming
- Riparian buffer creation – vegetated riverside land parcels that retain phosphorous
- Short Rotation Coppice – production of energy crops that remove phosphorous from land when harvested.

3. Analysis of the Efficacy of Mitigation Options

Mitigation solutions were divided into those that could be applied onsite and those that would need to be applied offsite. For the purposes of defining onsite and offsite, onsite solutions would need to be kept within the redline boundary for a development site.

3.1. Onsite mitigation solutions

3.1.1. Water efficiency measures

Reducing water usage can reduce phosphorous output from a wastewater treatment works (WwTWs) by reducing the flow of wastewater to a treatment works and thus reducing the amount of phosphorous the WwTW outputs. However, it is important to note that increasing water efficiency will only reduce phosphorous output from a WwTW that has dedicated treatment processes to remove phosphorous and regulated limits on the amount of phosphorous in the treated wastewater that discharges to the River Wye. Reducing the volume of water used within a household through water efficiency does not reduce the amount of phosphorous the household outputs, so increased water efficiency results in greater concentrations of phosphorous in the wastewater that goes to a WwTW. This means that at WwTWs without processes to limit phosphorous in the treated wastewater, water efficiency measures have a negligible impact on reductions in phosphorous outputs from the WwTW. Because of this issue, water efficiency solutions are not guaranteed to pass the HRA test of mitigating phosphorous inputs to the River Wye "*beyond reasonable scientific doubt"*.

There are other issues related to the longevity of water efficiency measures because they typically involve installation of water efficient bathroom and kitchen fittings. The long-term effectiveness of water efficiency measures is difficult to measure without household monitoring using smart meters and the potential for changes to less water efficient fittings over the lifetime of a development raises questions over whether this mitigation measure would pass the HRA test of "*in perpetuity*" reductions in phosphorous export. Where a development is council owned, greater control over the fittings used could be achieved, which may increase the viability of this measure. However, having two potential failures of the HRA tests means that water efficiency measures are not recommended as a potential mitigation option.

3.1.2. Onsite wastewater treatment

Package Treatment Plants (PTPs) are small wastewater treatment systems that are used for developments in locations that cannot be connected to mains sewerage. It should be noted that where developments can reasonably connect to mains sewerage, they are expected to by the Environment Agency. Being able to "reasonably" connect to mains sewerage is generally defined as being able to connect to a mains sewer without unfeasible engineering requirements. The phosphorous concentration in effluent from a PTP is dependent on the device used and there are now highly efficient systems available that can reportedly achieve phosphorous concentrations of < 1.5 mg P/l. The lower the phosphorous concentration in the final effluent, the less phosphorous will be produced annually by a development and thus the less mitigation that is required. If the effluent is then discharged to a well-designed and maintained soakaway or a wetland system, this system could retain enough phosphorous for the development to achieve nutrient neutrality. A PTP combined with a wetland/soakaway passes the four HRA tests.

3.1.3. Sustainable Drainage Systems (SuDS)

SuDS are an onsite solution for mitigating the phosphorous in surface water runoff from a development site during and after rainfall. SuDS are incorporated into the drainage design for a new development as a means of reducing surface water runoff rates to alleviate downstream flood risk, however SuDS can also have additional benefits for water quality, including the removal of phosphorous. There are various different components that can be incorporated into a SuDS design and help to remove phosphorous, however many of the components do not have a strong evidence base to support the efficiency of phosphorous removal each type of component could achieve. Constructed wetlands incorporated within a SuDS design have the most evidence to support their use for phosphorous removal and are likely to be able to play a role in mitigation for nutrient neutrality in the Wye SAC catchment. The key consideration in the use of SuDS and wetlands is scaling of the system. SuDS need to receive a sufficient volume of water and its associated phosphorous load to make meaningful reductions in phosphorous export to the River Wye. As an example, a hypothetical 100 dwelling development could generate ~12 kg P/year that would require mitigation, thus requiring a ~0.7 ha wetland draining ~17 ha of urban land to offset the additional phosphorous load from the new development. This suggests that SuDS would need to intercept runoff from land outside of the development redline boundary if the system is to be effective as a mitigation solution. The long-term performance of SuDS would also need to be secured through maintenance agreements. Assuming these issues can be addressed, SuDS pass the four HRA tests.

3.2. Offsite measures

3.2.1. Agricultural land abandonment and woodland planting/reversion to semi-natural habitat

Fertilisation and animal waste enrich agricultural land with phosphorous and increase phosphorous export to rivers relative to natural background levels. By abandoning agricultural land and halting fertiliser applications or removing animal waste inputs, phosphorous export to the environment is reduced and can provide a mitigation solution for new developments. Woodland planting can be used to secure agricultural land abandonment without land purchase, as it is easy to confirm that reforested land is remaining out of agricultural use. If land is being purchased, reversion to woodland or other semi-natural habitats, including orchards, can be used to secure the conversion from agricultural use. Woodland planting or facilitating and speeding up the reestablishment of semi-natural vegetation cover may also increase phosphorous uptake in the short-term. This could be important in tackling problems around “legacy” phosphorous, which is the phosphorous that gets left in the soil by agriculture and can potentially result in phosphorous export remaining elevated above natural background levels for a period of the order of 20 years after agricultural land has been abandoned. Other short-term management practices such as planting cover crops to avoid soil erosion can be used limit the problems of legacy phosphorous leaching.

It should be noted that woodland planting or semi-natural revegetation have large uncertainties associated with the scale of reductions in phosphorous export they can achieve and thus the number of phosphorous “credits” a reforestation-type scheme would provide in the short-term. These uncertainties could require monitoring to determine the amount of phosphorous one of these schemes is stopping from being exported to the River Wye and an effective ‘fall back’ or supplementary option would also be required. It is also important to note that whilst agricultural land abandonment/woodland planting schemes would pass the four HRA tests, the amount of land required for abandonment to mitigate a 100 dwelling development with a ~12 kg/yr phosphorous budget is likely to be in the region of 40 ha. The exact amount of land required depends on the type of farm, as well as soil drainage characteristics and the average annual rainfall the farm receives.

3.2.2. Riparian buffers

A riparian buffer is a thin strip of land with permanent vegetation cover that runs along the edge of a river, separating the river from adjacent land uses. These buffers reduce surface water flow rates and promote various mechanisms of phosphorous removal that lead to an improvement in river water quality. The main phosphorous removal mechanisms in riparian buffers are sediment capture, soil sorption (phosphorous binding to soil) and plant uptake of phosphorous. Riparian buffers can also provide additional reductions in phosphorous export to rivers through the stabilisation and reduced erosion of riverbanks, with associated reductions in the amount of phosphorous from soil and sediment particles that wash into rivers when banks are eroded. Riparian buffers have been shown to achieve good rates of phosphorous retention, but they require maintenance "*in perpetuity*". Without maintenance they can switch from a sink to a source of phosphorous. Maintenance mainly requires annual cutting and removal of vegetation.

Riparian buffers are also part of the toolbox of wider sustainable river catchment management to remove diffuse nutrient pollution problems. As such, there is a need to consider whether a location chosen for the deployment of riparian buffers for phosphorous mitigation already had plans for the use of riparian buffers as part of wider efforts to reduce diffuse phosphorous pollution to the River Wye. If this is not considered, there is a risk of double counting the potential phosphorous reductions provided by riparian buffers, as they will be counted once for offsetting the phosphorous from a new development and once for offsetting the phosphorous from diffuse agricultural sources.

Riparian buffers have the potential to meet the four HRA tests, but monitoring and maintenance are required to pass the tests of showing phosphorous reductions "*beyond reasonable scientific doubt"* and "*in perpetuity*". Riparian buffers could also provide a short-term, easy to implement measure for use whilst long-term measures are being established.

3.2.3. Short Rotation Coppice (SRC)

Energy crops such as poplar and willow can be grown on former arable land or on riparian buffer strips. These crops can remove up to 15.8 kg of phosphorous per 10 oven dry tonnes (ODT) per hectare per year. They can be grown in phosphorous enriched soils without any fertiliser inputs and their uptake of phosphorous and subsequent removal through harvesting could provide a reduction in phosphorus export to the Wye above simple agricultural land abandonment. Depending on the soil phosphorous content, SRC plantations may start requiring additional nutrient inputs before the end of their productive life. There is a potential to use sewage sludge for fertilisation in a closed-loop system of nutrient use, though caution will be required to ensure crops are not over-fertilised, which could result in phosphorous export from the plantation. Harvesting needs to be completed every 2-4 years. Harvested crops can be sold as fuel, which then removes phosphorous from the River Wye catchment system. SRC plantations may only remain productive for around 30 years before the trees need replacing. This mitigation solution passes three of the four HRA tests, with only question mark over the "*in perpetuity*" test due to the requirement to replace trees after 30 years. However, a system of SRC plantations that are managed to overlap in time could get around the issue of providing phosphorous removal *in perpetuity*.

3.2.4. Wetlands

Wetlands can be deployed "in catchment", i.e. in different locations around the River Wye catchment, in order to remove phosphorous from surface water runoff or stream flow. Alternatively, wetlands can be built to at WwTWs to remove phosphorous from the final treated effluent before it discharges to a river. Wetlands comprise constructed waterbodies designed to filter and treat water pollutants found in domestic sewage, municipal sewage, industrial effluent, stormwater runoff, and agricultural runoff. The main phosphorous removal mechanisms in wetlands are the deposition of phosphorous that is bound to particles, sorption (binding) of dissolved phosphorous to sediment and plant uptake of bioavailable phosphorous. These processes are affected by many wetland and water quality characteristics including: wetland size, flow velocity through the wetland, water retention times, water and air temperature, types of vegetation, wetland management regimes, concentrations of phosphorous in the inflow to the wetland and the type of wetland. Due to the highly variable nature of these key characteristics, reported phosphorous removal rates are also highly variable. Studies of wetlands suggest that they can achieve an approximate average phosphorous removal of 60% of the inflow phosphorous concentrations for urban wetlands and 46% for wetlands with a variety of sources of water. However, given the elevated concentrations of phosphorous in inflows to wetlands, especially from WwTWs effluent, even a 46% treatment efficiency provides a significant mitigation potential and it is likely that efficiencies much greater than 46% can be achieved through suitable design.

As deposition of phosphorous that is bound to sediment particles is the main phosphorous retention mechanism in wetlands, they can switch from a sink to a source of phosphorous. Therefore, desilting/desludging needs to be completed to ensure optimal phosphorous removal *in perpetuity*. Vegetation also needs to be managed to remove phosphorous accumulated within the vegetation from being re-released when it dies and decomposes in the wetland. Wetlands will need comprehensive wider management plans that include disposal of removed sediment and vegetation in ways that do not recirculate phosphorous through the Wye catchment. Assuming these maintenance requirements can be secured *in perpetuity*, wetlands provide a very promising mitigation option that can provide significant reductions in phosphorous export to the Wye SAC and that pass the four HRA tests.

4. Recommendations

Based on the analysis conducted for the Interim Phosphate Delivery Plan Stage 2: Mitigation Options for Phosphate Removal, the following key recommendations were made:

- Wetlands at WwTWs are likely to provide the best strategic mitigation option, with the potential to offer a significant number of phosphorous “credits” to offset phosphorous from new developments.
- Consideration should be given to small wetland schemes “in catchment”, such as ponds or linear wetland features that could be quick to deliver, cheap and provide a good number of “credits”.
- Deployment of certain types of larger wetlands “in catchment” to intercept surface water runoff in areas of known high phosphorous sources could also provide good mitigation solutions whilst also providing additional habitat and amenity benefits.
- Combining riparian buffers and SRC in a hybrid option could provide another solution to remove notable amounts of phosphorous with other additional environment benefits but is likely to require more research.
- More research into the potential phosphorous removal from reforestation would potentially help provide support to reforestation schemes using developer contributions towards nutrient neutrality and provide wider environmental net gain.
- High efficiency PTPs provide a robust onsite engineered solution, but it is suggested that approaches with additional nature benefits should be considered where possible.