Impact of Dambridge WwTW on nutrient load in Stodmarsh SSSI – initial scoping study

Dover District Council

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Contents

1. Introduction

1.1 The nature of the problem

The Stodmarsh wetland complex, comprising a series of open water lakes, reedbeds and marsh, is situated adjacent to the upper tidal reach of the Great Stour River east of Canterbury. It has historically suffered from eutrophication as a result of excessive nutrients entering from the catchment. The Stodmarsh Lakes system is an important habitat that holds various statutory designations: Site of Special Scientific Interest (SSSI), Ramsar site, Special Protection Area (SPA) and Special Area of Conservation (SAC). The north eastern half of the system is a National Nature Reserve (NNR). As a freshwater site, it is failing both nitrogen and phosphorus standards for favourable condition of Natura 2000 sites, with potential impacts on important wildlife for which it is designated (Natural England: *Stodmarsh and Nutrients – Non-Technical Summary*, November 2020).

Controlling the negative impact of excessive nutrient input into Stodmarsh requires several measures, including ensuring no further increase in nutrient loading from new developments. Following the issue of Natural England guidance on achieving nutrient neutrality for Natura 2000 sites, all local authorities in the catchment affecting Stodmarsh SPA are required to apply the guidance package and follow Habitats Regulations Assessment to stage 2 Appropriate Assessment, before any planning applications for development in the catchment can be granted. Development of new housing, including that within the new local plan, must demonstrate nutrient neutrality.

In the case of Dover District Council (Dover DC), only a small proportion of the River Stour catchment is within the local authority boundary, and this is within the lower reaches of the Little Stour sub-catchment. The Little Stour joins the Great Stour approximately 7 km downstream of Stodmarsh SPA, being pumped up to the level of the tidal reach by Stourmouth Pumping Station. Therefore, any nutrient inputs from Dover DC would need to be transported upstream by this distance to enter the SPA. Despite the small proportion of the catchment area within its jurisdiction and low probability of impact, it is important that Dover DC has a full understanding of its role in affecting nutrient loads in Stodmarsh SSSI, in order to enable further development to proceed without having any further impact on the site.

1.2 Dambridge WwTW

The specific issue within the Dover DC area is Dambridge wastewater treatment works (WwTW). In common with other WwTWs, it discharges treated final effluent to the environment. This final effluent contains nutrients (nitrogen and phosphorus) which are the determinands of interest to this report.

The final effluent from Dambridge WwTW drains via the Wingham River to the Little Stour and then (at its confluence with the Great Stour) to the River Stour, finally reaching the North Sea/English Channel in Pegwell Bay south of Ramsgate. The land is very flat and the River Stour/Great Stour/Little Stour are tidal for up to 30 km inland – the Great Stour as far as Fordwich near Canterbury, and the Little Stour as far as West Stourmouth, downstream of the Wingham River confluence.

Dambridge WwTW may in future have to accept increased input flows due to new housing developments. This may in turn result in higher discharged nutrient loads. Concern has been expressed that, under certain conditions of tide and river flow (in particular low river flow/drought conditions combined with high tides), nutrients discharged from Dambridge WwTW may be carried downstream to the Little Stour/Great Stour confluence, then back upstream in the Great Stour under the rising tide to enter and potentially impact the Stodmarsh Lakes system.

1.3 Project aim

The aim of this scoping study is to provide an initial assessment of whether nutrients within the consented effluent discharge from Dambridge WwTW have the potential to affect nutrient loading into Stodmarsh SPA.

Following upgrading of the sluice and construction of bunds at Stodmarsh, unplanned overtopping of the Great Stour into the SPA and reserve will only take place during extreme flow (1 in 10-year flooding) (Phil Williams, Natural England, *pers. comm*.). Water moving upstream from the Little Stour would only enter the SPA as part of a controlled inflow, which will only occur during drought conditions to maintain water levels and stop drying of the wetland complex. Therefore, the assessment looks specifically at conditions during drought periods.

As an initial scoping study, the assessment aims to either demonstrate that Dambridge WwTW can have no impact or, if an impact is possible, to identify the further data collection and approaches that may be needed to demonstrate and quantify an impact.

2. Approach followed

This scoping study was undertaken in two stages:

1) confirming the influence of Dambridge WwTW on nutrient concentrations in the Great Stour; and, if this is significant,
2) identifying a method for determining the upstream movement of nutrients from the Great Stour/Little Stour confluence to Stodmarsh.

Only phosphorus loads have been considered as part of stage 1, because of the absence of nitrogen data from the effluent discharges. However, for the purposes of this assessment a demonstrable impact of Dambridge WwTW on River Stour phosphorus concentrations is expected to be matched by an equivalent impact on nitrogen concentrations. If application of stage 2 proposals demonstrates a measurable upstream movement of water to Stodmarsh, then readings of oxidised nitrogen concentrations may be required from effluent discharges, to confirm the scale of impact.

2.1 Influence of Dambridge WwTW on nutrient concentrations

A simple mass balance calculation was undertaken to confirm the role of Dambridge WwTW in influencing nutrient concentrations in the Great Stour. This takes concentration of nutrients in the consented effluent from the WwTW and combines them with flow readings to work out a daily load (in kilograms) added to the river system in the discharge. By carrying out the same calculation for other rivers and WwTW discharges, an overall daily load immediately downstream of the confluence of the Great Stour and Little Stour was estimated. The proportion of this deriving from Dambridge WwTW was then determined.

As the impact of Dambridge WwTW on overall load was anticipated to be high, a simple calculation based on mean nutrient concentrations was followed. Details of the method for determining flow and nutrient load are given in Appendix 1.

Even allowing for potentially large variability in the estimated concentration, due to changes in river flow and discharge volumes, and to temporal fluctuations in nutrient concentrations, the phosphorus load from Dambridge WwTW into the Great Stour is measurably large, with potentially up to 5% of the total (see Appendix 1), although with around 1-2% as a more realistic possibility, and cannot therefore be discounted.

The investigation therefore proceeded to the second stage.

2.2 Upstream movement of nutrients to Stodmarsh

Upstream movement of nutrients is determined by the capacity of tidal inflows, normal river flow always being downstream. While an incoming tide will cause some upstream movement of water, even in the upper reaches of an extended tidal river such as the Great Stour, it is difficult to determine whether this upstream movement could ever extend as far as Stodmarsh.

A simple mass balance approach would suggest that this is unlikely to occur, as even at a very low flow (Q95[1]) the Great Stour (including Canterbury WwTW) would be adding over 50 Ml of fresh water, which could fill the river channel completely for several km, over each tidal cycle, and upstream movement would have to push this upstream by at least an equivalent distance over several high tides. However, this does not account for the full complexity of water mixing and movement in such a system. Nor does it consider the large inline lake east of Westbere.

This scoping study therefore looked at options for accurately investigating upstream movement and has identified a modelling approach that will be required to investigate it fully.

The modelling approach has been developed in association with Intertek Energy & Water. This is a leading international consultancy providing specialist services using numerical models to understand, quantify and visualise complex water environments. It has developed its own river modelling packages specifically to address Urban Pollution Management (UPM) and Water Framework Directive (WFD) requirements, as well as using packages such as MIKE11 and MIKE 21. Intertek's CATCHMENT-OPTIMISER river modelling package is currently used by many of the UK's water and sewerage companies

The approach is described below and is presented as a proposal for further work, should it be required. A timetable and indicative fee is given in Section 4.

[1] The minimum flow that occurs 95% of the time.

3. Upstream movement model

3.1 Model components

The general scope of the proposed modelling approach is as follows:

a) Undertake a data review and gap analysis, and prepare an accompanying report, to support the modelling study;
b) Construct an appropriate model of the Stour river system that is capable of modelling both flows and pollutant transport in the area of interest; and
c) Undertake model runs to determine whether there is connectivity between Dambridge WwTW and the entry point to the Stodmarsh Lakes system, and if so, under what conditions.

We understand that the study scope is only concerned at this stage with transport of pollutants to the entry point of Stodmarsh Lakes system. Any consideration of transport and dispersion within the Stodmarsh Lakes system, and corresponding nutrient-related impacts, would fall under a separate assessment and is not covered by the proposed approach outlined below.

3.2 Data review and gap analysis

The first phase of work required is to undertake a data review and gap analysis. This will focus on the data required for the river model build and connectivity assessment but may also consider requirements for later stages of work (e.g. a potential future water quality study to model nutrient concentrations).

The following bullets give a brief, high level overview of the key data requirements, sorted according to the availability of data as presently understood.

1) Data that are currently available and identified:
    - River flow gauging from Environment Agency (EA) monitoring sites (required for both upstream inputs and calibration/validation of the river model).
    - Downstream tidal levels. These have not been sought as part of this scoping study, but may be obtained from an Intertek coastal model, from tide gauge measurements if available, or from harmonic re-predictions based on tidal constituents for a nearby port (e.g. Ramsgate).
    - WwTW discharge flows (from measurements, estimates or permit limits). For the connectivity study, these are only required for WwTWs where the discharge flow may be hydrologically significant. Data from all Southern Water Services WwTWs are available, and likely to be the only relevant discharges. However, any significant private treatment facilities, including those associated with the zoos in the Little Stour catchment, would need to be checked for flow volumes.
    - Surface salinity and water quality sampling data from a variety of sites in the Stour river system (although salinity is of primary concern to the connectivity study). The EA has a series of sampling locations along the tidal Stour system, which will provide adequate coverage.

2) Data that should be available but have not yet been searched for:
    - Rainfall time series (although these data may not be required because the study is primarily concerned with base flows under dry conditions).

3) Data that may not be available and may need to be collected through targeted field surveys:

- River channel cross-sections (up to the tidal limits and potentially beyond). The spatial frequency of the required cross-section data depends on a number of factors, which include: channel slope (virtually negligible for the tidal Stour system); changes in channel shape; presence of bends in the channel; and the presence of structures such as bridges which may constrain the flow. It is hard to be prescriptive at this stage of the study, but as a rough indication, cross-section data may be required every 1 km along each stretch of the Stour river system, with potentially closer spacing at locations such as channel bends or bridges. Cross-sections would be required at least up to the tidal limits, and possibly beyond since there may be benefits in placing the upstream model boundaries some way upstream of the tidal limit.
- Vertical conductivity, temperature and depth (CTD) profiles to indicate the presence, or otherwise, of stratification within the river – in particular the presence of any saline wedge or mixing layer. EA sampling only considers surface water, whereas a full depth profile gives an indication of differential movement of surface and deeper water. This is common in upper estuarine systems, where the heavier salt water from the sea remains close to the bed and creates a ‘salt wedge’ with different properties to the lighter freshwater moving above it.

A potential challenge that may need consideration is the requirement to obtain data under representative environmental conditions. In particular, the most valuable flow and water quality (salinity) measurements would be those obtained during the particular environmental conditions targeted by the study, i.e. low river flow and high tide conditions. Such conditions will be more likely and frequent in the summer months, although an extended winter or spring dry period, as occurred 2020, would also provide the required conditions. This requirement may therefore delay delivery of the model if the data are not already available.

The deliverable from this phase of work will be a Data Review and Gap Analysis report. This will identify any data gaps and make recommendations for field surveys required to fill these gaps, but will not in itself comprise a detailed survey specification.

3.3 River model development

We recommend the use of the specialist MIKE 21 tool for the river model development and subsequent applications. This is a two-dimensional modelling package that is able to simulate along-channel and cross-channel variation within a river. The one-dimensional MIKE 11 modelling package offers an alternative approach and is more frequently used for river modelling. However, we recommend the MIKE 21 approach for several reasons:

- MIKE 21 is better able to simulate two-way flow (i.e. including upstream transport), which is a key element of the connectivity study.
- A MIKE 21 river model would be able to interface directly with a MIKE 21 coastal model, which may be the preferred means of defining downstream hydrodynamic and water quality boundaries. Intertek holds suitable MIKE 21 models of the required coastal region, which may be available for use with the agreement of the model owners.
- Although we do not presently envisage the need for a three dimensional (3D) model, if it becomes necessary in the course of the study to consider 3D effects (i.e. vertical stratification within the river channel), MIKE 21 can be converted to the required MIKE 3 approach while MIKE 11 cannot.
- The use of MIKE 21 future-proofs the model to a certain extent, since, should it be necessary at a later stage to model the Stodmarsh Lakes system, this could be done within MIKE 21 and would require no special interface with the MIKE 21 river model.

As indicated above, we do not propose to include the Stodmarsh Lakes system within the river model for the connectivity study since the focus is on whether or not there is connectivity between Dambridge WwTW and the entry to the lakes system. We will, however, include the lakes system as a source and/or sink of flow.

The river model would be constructed using the data identified in the Data Review and collected during any subsequent field surveys, as summarised in Section 3.2. At present, there are significant gaps in the data that are understood to be available for the model development and applications. These gaps would need to be filled as best as possible, but it may be that the initial model development and connectivity study are necessarily high level and may need to be refined at a later stage.

Upstream flow inputs to the river model would be provided from suitable EA gauging in order to calibrate and validate the river flow model for selected time periods. For the actual connectivity study, upstream flow inputs will be specified to represent the required low flow conditions.

The downstream river model boundary will be specified in one of two ways:

1) The river model will be built as an extension of an existing MIKE21 coastal model. This approach may be preferred since it will allow interactions between the fluvial and coastal environments, e.g. in terms of freshwater mixing.
2) The downstream boundary will be specified as a water level boundary with levels taken from a coastal model, or a suitable local tide gauge, or tidal level re-predictions based on suitable local harmonic constituents. This approach is potentially quicker and simpler than using a coastal MIKE 21 model but would require certain assumptions to be made (e.g. any coastal water flowing upstream enters the model domain as fully saline marine water).

The preferred approach to defining the downstream boundary will need further consideration during the course of the study.

River flow model calibration will be undertaken by modelling one or more time periods and adjusting parameters within the model in order to achieve an acceptable fit of predicted flows against flow data measured at the gauging stations (in particular the station at Pluck's Gutter, just downstream of the Great Stour/Little Stour confluence). Flow model validation will be undertaken by modelling different time periods in order to test how well the model replicates measured flows, without making further changes to the model parameterisation. Often, river model applications are more concerned with high flows (e.g. for flooding or high impact water quality studies) and the calibration and validation therefore focuses on wet weather events. For the required connectivity study, we propose to place more emphasis on low flow / drought conditions. As such, the validation exercise may be very similar to the calibration and may not add much value to the model development.

Given the known availability of data at present, calibration and validation will also be limited to a small number of locations for which long-term measurements are available.

Since the initial study focuses on connectivity between Dambridge WwTW and the Stodmarsh Lakes system, there is no identified requirement to calibrate the model for water quality, other than consideration on the potential influence of salinity/temperature stratification on transport and mixing. As such, nutrient data are not required.

3.4 Connectivity study

We propose the following key activities for the connectivity study:

- Model discharge from Dambridge WwTW. The study aim is to assess whether there is connectivity between this discharge and the entry point to the Stodmarsh Lakes system. As such, modelling of water quality parameters such as nutrients, and precise characterisation of the WwTW discharge load, is not required.
- Undertake model runs for a range of river flow and tidal height conditions, with the key focus being on low river flow and high tide conditions under which connectivity is more likely. These runs will identify various combinations of river flow and tidal height (if any) that lead to connectivity.
- Use historic measurements of river flow and predictions of tidal height to specify the likelihood (percentage frequency) of these connectivity conditions occurring. Since this calculation requires a measure of joint probability between river flow and tidal height, we propose to treat these two variables as independent of one another. This is a reasonable approach since there is no obvious mechanism by which tidal state can influence river flow above the tidal limit, or vice versa.

The deliverable from the connectivity study will be a technical report that covers at least the following study elements:

- scope and requirement;
- background data (with reference to the Data Review and Gap Analysis where relevant);
- connectivity study method;
- results from the connectivity study; and
- conclusions and recommendations.

The report will include GIS plots, river stage plots, supporting tables etc. as required.

4. Timetable and cost

4.1 Timetable

The individual modelling components are relatively rapid, with estimated sequential delivery times as follows:

- Data review, gap analysis and report: 3 weeks
- River model build, calibration and validation: 5-8 weeks
- Connectivity study and technical report: 3-5 weeks

However, the indicative timescales for the model build and connectivity study would start from the receipt of all relevant data. If channel cross-section and depth profile field data are required, then these could be collected within 2-3 weeks, in a single data collection campaign; although this is subject to the availability of the required low river flows and, ideally, high tides.

It is possible that cross-section data already exist, as part of EA flood models, but time would have to be allowed to retrieve these data and to confirm that they cover the river adequately for the MIKE 21 model.

It is unlikely that adequate depth profile data currently exist.

4.2 Cost

An estimate of the maximum cost of delivering the modelling approach described above is summarised below:

Data review, gap analysis and report:	£5000[2]
River model build, calibration and validation:	£11,000
Connectivity study and technical report:	£9000
Total	**£25,000**

If the cross-section and depth profile data are required, then the cost will be determined by the gaps in the data. A realistic estimate if no data are currently available would be within the range **£15,000** to **£25,000**, depending on precise locations required. We must emphasise, however, that most of the data required may already be in existence, and with this in mind have requested access to the data underpinning the River Stour flood model from the EA. If only spot depth profile data are required, a cost nearer **£5000** is more realistic.

Note that the fee estimates are exclusive of VAT.

If you wish to pursue the assessment to the next stage, we would propose that the data review, gap analysis and report is commissioned initially, as this will determine field data needs and therefore enable precise costing of this component.

[2] This is expected to be reduced considerably if a formal quote is required, as much of the required flow and water quality data has already been identified and collated.

Appendix 1 Nutrient loading to the River Stour

A. Justification for method used

To provide an idea of potential for Dambridge WwTW to be contributing a measurable concentration of nutrients to the Great Stour, and therefore to have the potential for these to be carried upstream to Stodmarsh, a simple mass balance approach was followed. This approach is based on single summary values for flow and nutrient concentration, rather than accounting for variation or interaction between the variables, and should therefore be interpreted only as indicative rather than a definitive measure of impact. It is, however, valuable as a rapid tool for determining what further analysis may be required.

B. Data available

The following data were available for this scoping assessment.

A1 River flow data

The National River Flow Archive (NRFA) contains data from two active flow gauges and one disused flow gauge in the immediate catchment.

a) Great Stour at Horton. This is situated upstream of Canterbury and records flow from the majority of the Great Stour catchment upstream of the tidal limit at Fordwich. No further tributaries enter the river between this gauging station and the tidal reach, although there is catchment runoff in Canterbury and the treated effluent discharge from Canterbury WwTW.
b) Sarre Penn. This is a tributary situated north of Canterbury. The water from this enters the River Wantsum which then flows north, but there is also a hydrological connection south to the tidal Great Stour c. 500 m upstream of its confluence with the Little Stour. For the purposes of this assessment, southward flow was considered minimal and the data from this gauging station was not included in the assessment.
c) Wingham at Durlock. This is situated on the Wingham River 2.5 km upstream of Dambridge WwTW. It is no longer operational, having been closed in 2007.

The EA Hydrometric Data archive contains data from two active flow gauges of relevance to this assessment.

d) Little Stour at Littlebourne. This is situated upstream of the Wingham River confluence.
e) Great Stour at Plucks' Gutter. This is situated immediately downstream of the Little Stour confluence in the tidal reach of the river.

A further tributary of the tidal Great Stour was considered: Lampen Stream flows into the Great Stour via Stodmarsh SPA. However, this was not considered relevant to this assessment because, during drought conditions when Stodmarsh water is to be supplemented from the Great stour it is assumed that all the Lampen Stream inflow is retained with in the wetland.

A2 River water quality data

The area has an extensive coverage of EA water quality monitoring stations, and data from six of these were relevant to this assessment (Table A 1). These are typically monitored monthly or quarterly, and all are sampled for key nutrient indicators: nitrate as N, nitrite as N, total oxidised nitrogen and reactive orthophosphate as P. Data from January 2016 to July 2020 were used in the analysis.

Table A 1: Environment Agency water quality monitoring station data used in the assessment

Sample site name	River	NGR	Number of samples
Durlock Gauging Station	Wingham River	TR 27500 57582	17
A257 Wingham	Wingham River	TR 24382 57836	18
Little Stour Littlebourne	Little Stour	TR 21100 57400	16
White Bridge Little Stour	Little Stour	TR 21617 58292	25
Little Stour Blue Bridge	Little Stour	TR 24232 62044	19
Great Stour Grove Ferry	Great Stour	TR 23500 63200	36

A3 Effluent discharge data

Effluent volumes were derived from Southern Water at https://www.southernwater.co.uk/our-performance/flow-and-spill-reporting. This provides daily discharge data from all WwTWs for the previous five years.

The key volume data was for Dambridge WwTW, but three other WwTWs were included in addition.

a) Newnham Valley WwTW discharges into the Little Stour between the Wingham Stream confluence and its tidal reach.
b) Canterbury WwTW discharge volumes were used to calculate overall discharge volume of the Great Stour into its tidal reach.
c) Westbere WwTW discharge volumes were used to calculate overall discharge volume of the Great Stour into its tidal reach.

Effluent water quality data was derived from the EA UWWTD monitoring database. Data from January 2016 to July 2020 were accessed for the analysis.

Total phosphorus concentration is monitored at Dambridge WwTW. In order to compare this with river water quality data, a conversion to estimated orthophosphate concentration was therefore applied. This was derived from data collected by APEM as part of flow and load assessment of treated effluent discharge at a series of WwTWs in North Wales, making an assumption that domestic treated effluent would be of a similar composition to that at Dambridge WwTW. The details are provided below.

No phosphorus quality data are analysed from Newnham Valley final effluent samples, so the same composition as Dambridge WwTW was assumed.

No nitrogen analysis is carried out on the final effluent at Dambridge WwTW, and only ammoniacal nitrogen at Newnham Valley WwTW. Therefore, at this stage a specific nitrogen load calculation is not possible.

No effluent quality data were determined or estimated for Canterbury or Westbere WwTW, as their water quality impacts contribute to the combined nutrient concentrations recorded at Grove Ferry.

C. Orthophosphate concentration in treated effluent

Normally, as in the case of Dambridge WwTW, when phosphorus is monitored in final effluent discharges this is limited to total phosphorus, whereas in rivers orthophosphate, the bioavailable form of phosphorus, is measured. Therefore, in order to provide comparable phosphorus data from the final effluent, a conversion to estimated orthophosphate concentration was required.

In 2016 APEM carried out a series of flow and load assessments on behalf of Dŵr Cymru Welsh Water at several rural WwTWs in North Wales. These included measurements of both total phosphorus and orthophosphate. This dataset was used to investigate the relationship between the two in the samples, which was determined to be linear (Figure A 1). Using the equation from which the straight line was derived:

$$Y = 0.85632X - 0.0087$$

This was applied to Dambridge WwTW total phosphorus data to estimate the orthophosphate concentration.

$$\text{Orthophosphate concentration} = (\text{total phosphorus concentration} \times 0.8562) - 0.0087$$

This was applied to each sample concentration separately.

Total phosphorus was not measured in Newnham Valley WwTW final effluent, so the mean concentration from Dambridge WwTW was applied to this.

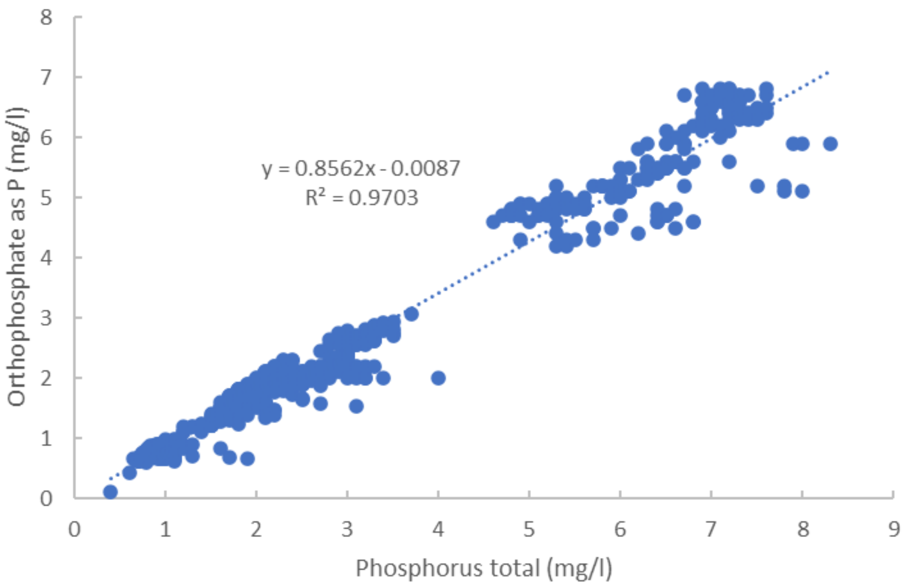

Figure A 1: Relationship between total phosphorus and orthophosphate concentration in treated effluent

Based on a mean total phosphorus concentration in Dambridge WwTW effluent of 1.513 mg/l, the estimate orthophosphate concentration is 1.287 mg/l. This concentration is consistent, with a standard deviation of 23% of the mean.

D. Method for determining flow and load estimates

As ingress of water from the Great Stour to Stodmarsh reserve is only anticipated to occur as a planned activity during drought conditions, an assessment was made assuming river flows are very low. Treated effluent discharge volumes are less affected by low rainfall than river flows, so assuming mean discharge volumes from WwTWs provides a precautionary approach when considering maximum potential impact of effluent discharge on water quality. Therefore, river flows used for the Great Stour, Little Stour upstream of Wingham River and Wingham River itself were Q95 flows. Discharge flows used for all WwTWs were mean flows (Table A 2).

It is acknowledged that other sources of water will contribute to the flow of all the rivers assessed, and that these will further dilute the inputs from Dambridge WwTW. Comparing calculated flow at Pluck's Bridge from addition of all measured inputs (Table A 2 , row 11) to actual measured flow(Table A 2, row 12), these extra sources add an extra 17% to the total.

Table A 2: Flow estimate for the rivers and WwTWs

Row	Site	Data time period	Flow type	Estimated flow	
				(m^3/s)	Ml/day
1	Wingham River (excl. Dambridge WwTW)	1964-2007	Q95	0.001	0.09
2	Dambridge WwTW	2015-2019	Mean	0.029	2.50
3	Wingham River total at A257 crossing	N/A	Estimated Q95 (row 1+2)	0.030	2.59
4	Little Stour at Littlebourne	2003-2020	Q95	0.067	5.79
5	Newnham Valley WwTW	2015-2019	Mean	0.044	3.84
6	Little Stour total at Blue Bridge (incl. Wingham River and Newnham Valley)	N/A	Estimated Q95 (row 3+4+5)	0.141	12.21
7	Great Stour at Horton	1964-2019	Q95	1.030	88.99
8	Canterbury WwTW	2015-2019	Mean	0.229	19.79
9	Westbere WwTW	2015-2019	Mean	0.017	1.48
10	Great Stour at Grove Ferry	N/A	Estimated Q95 (row 7+8+9)	1.276	110.25
11	Great Stour at Pluck's Gutter		Estimated Q95 (row 6+10)	1.417	122.46
12	Great Stour at Pluck's Gutter	2015-2020	Q95 (actual)	1.700	146.88
13	Flows not accounted for		Percent (row 11/row 12)	17%	

Mean recorded orthophosphate concentrations are provided in Table A 3.

.

Table A 3: Orthophosphate concentrations in river and effluent water

Row	Site	Orthophosphate as P concentration (mg/l)	
		Mean	1 standard deviation
1	Great Stour at Grove Ferry	0.232	0.073
2	Little Stour above Wingham River confluence (White Bridge)	0.025	0.013
3	Newnham Valley WwTW effluent	1.287	0.031
4	Little Stour below Newnham Valley outfall (Blue Bridge)	0.244	0.067
5	Wingham River at Durlock	0.340	0.383
6	Dambridge WwTW discharge	1.287	0.031
7	Wingham River at A257	0.596	0.386

The estimated mean daily load of orthophosphate as P in the Wingham River downstream of Dambridge WwTW[3] is 1.54 kg. The estimated total mean daily load at Pluck's Gutter, at Q95 flow[4], is 28.57 kg. This would give a contribution from Dambridge WwTW of approximately 5% of the total. This is an over-estimate, as P discharged from the WwTW will be removed by biological uptake and physical deposition as it moves down the river. Considering the Dambridge WwTW measurements alone, these would give an estimated load from the WwTW of over 3 kg/day, whereas the readings taken from the river are half of this, and further removal is expected. Therefore, a more realistic estimate of Dambridge contribution to the overall load at Pluck's Bridge is likely to be 1 - 2%.

Even allowing for unmeasured inputs and variations in nutrient concentration under different flow conditions (which this simple calculation has not taken into consideration), the nutrient contribution from Dambridge WwTW is measurably large and cannot be discounted as a contributor to overall nutrient load in the Great Stour.

[3] Calculated using the flow [Table A2, row 3] and the concentration [Table A3, row 7]
[4] Calculated using the flow [Table A2, row 12] and the estimated loads from each river: Little Stour - Table A2, row 6 and Table A3, row 4; Great Stour - Table A2, row 10 and Table A3, row 1.