

Maelor Foods Wrexham - Proposed Increased Discharge Impact Assessment

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April 2022

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Maelor Foods Wrexham - Proposed Increased Discharge Impact Assessment

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Summary

WRc was engaged by Maelor Foods Ltd in 2015 to assess the impact of their proposed discharge at their new site in Wrexham. Maelor Foods now wish to understand the impact of doubling their current discharge from its poultry plant and has engaged WRc to undertake an assessment of this increased flow.

A water quality modelling assessment has been carried out for a proposed increase in discharge by Maelor Foods Ltd to the River Dee in Wrexham. The assessment used the Environment Agency's River Quality Planning (RQP) Monte Carlo tool to model the effect of the discharge on the downstream river quality, specifically for determinands: BOD, ammonia, total phosphate and pH. A mass balance spreadsheet tool was used to model the resultant river temperature downstream of the discharge.

The river quality modelling using RQP showed that the predicted impact of the increased discharge on downstream river quality is small, with most quality determinands showing no change. Any predicted change in quality was small, especially in the context of uncertainty in the upstream flow data.

This was also reflected in the monthly temperature modelling, which showed a very small increase in temperature, apparent only at the second decimal place, under both average and Q95 (low) flow conditions in the river.

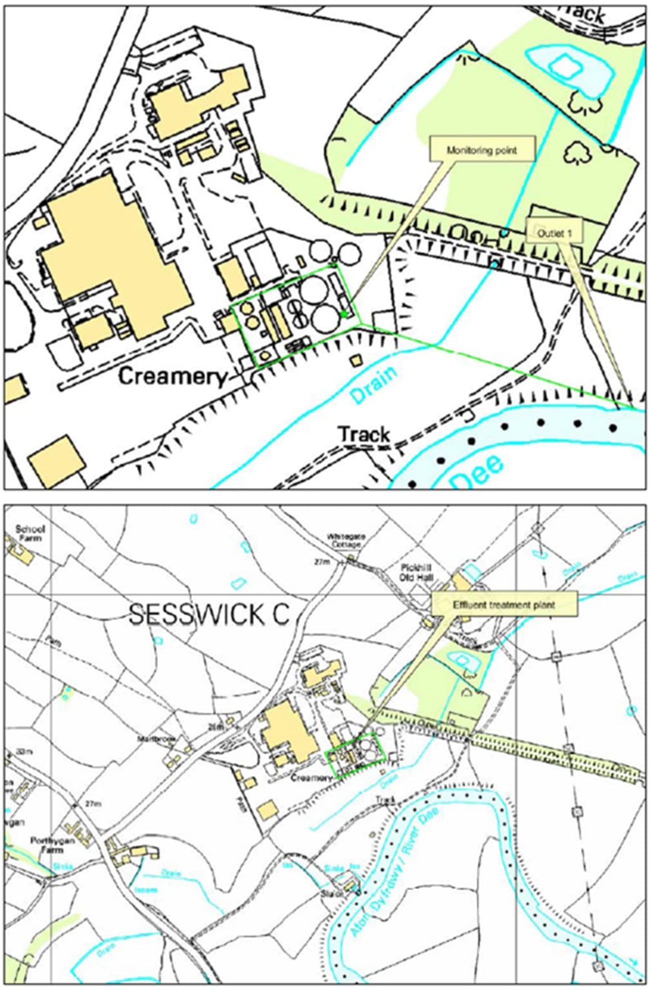
The results were based on proposed discharge flows of an average 2,400 m^3/d and a maximum 3,120 m^3/d, with quality based on the discharge concentrations currently permitted at the site. The results showed negligible impact at this loading (flow and concentration) from the discharge.

1. Introduction

1.1 Background

Maelor Foods Ltd, a subsidiary of Salisbury Poultry Ltd, is to increase weekly processing potential within its poultry plant, 4 km southeast of Wrexham. It has been proposed that weekly throughput is to be doubled from the currently permitted 1 million birds per week, to 2 million birds per week. The approximate location of the site is shown in Figure 1.1.

Figure 1.1 Site plan from previous permit.



In 2015, WRc was commissioned to undertake a permit modelling assessment for the proposed discharge from the Maelor poultry plant into the River Dee.

In 2022, WRc was again commissioned to undertake a modelling assessment for a proposed doubling in discharge. The same modelling tool was used to assess the water quality impacts of the current and proposed increased discharge flows. This was to understand the current and future impacts of the discharge on the River Dee. To do this, the upstream river flow and water quality was updated based on the latest observed data.

1.2 Determinands

The assessment was required for the following determinands:

- BOD
- Total suspended solids
- Ammonia
- Phosphate
- Iron
- Aluminium
- Temperature
- pH

1.3 Modelling tool

The Environment Agency's (EA) River Quality Planning Monte Carlo modelling tool is the most appropriate way of completing the impact assessment for all determinands, except temperature, as it can be used to predict the impact of point source discharges on receiving waters.

Temperature was modelled with a spreadsheet tool developed by WRc, rather than the River Quality Planning tool, as assessment of the impact of a discharge on temperature is required on a month-by-month basis and it is not possible to do this in RQP. A monthly assessment is required because the effluent is to be discharged above ambient river temperatures, which will vary throughout the year.

2. Data and Methodology

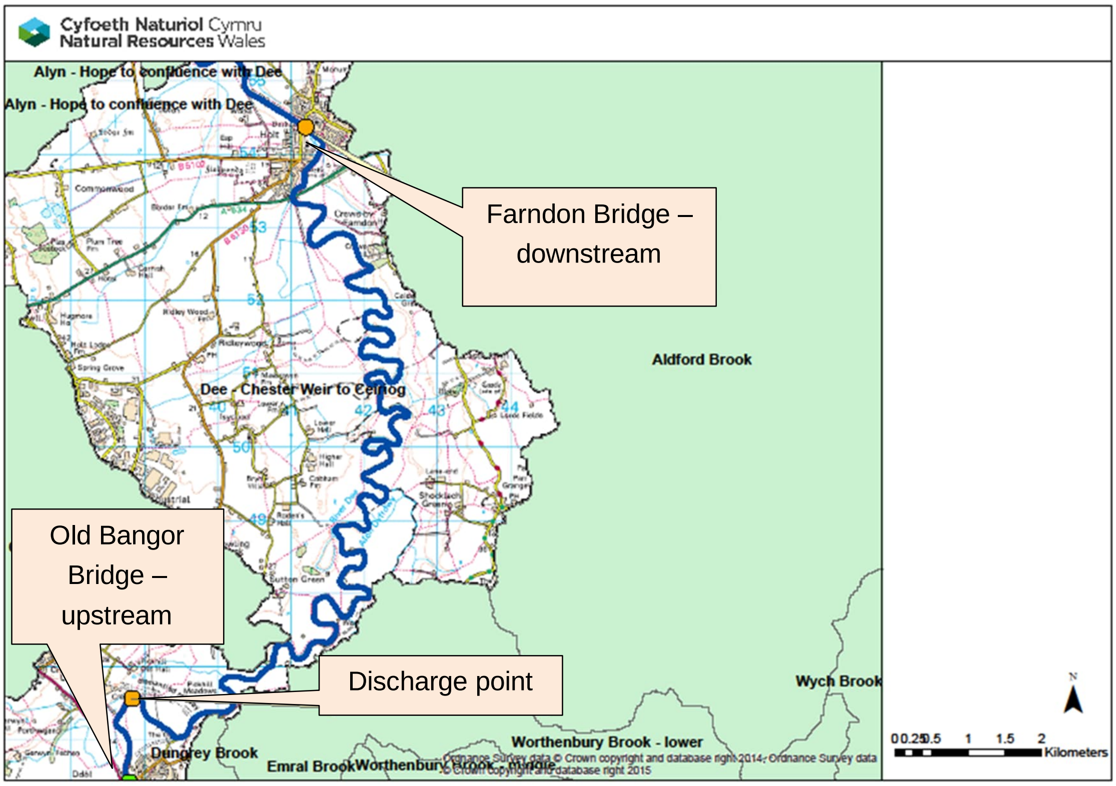
2.1 Upstream river flow and quality

Data for the river quality upstream and downstream of the proposed discharge were supplied by Natural Resources Wales (NRW) as a spreadsheet of approximately monthly values taken at two sampling points (Figure 2.1). The two sites were:

1. ID 87 – River Dee at Old Bangor Bridge, which is located 1.5 km immediately upstream of the discharge site. Grid Ref SJ 38780 45439

2. ID 671 – River Dee at Farndon Bridge, which is approximately 20 km downstream of the discharge site. Grid Ref SJ 4117054370

Figure 2.1 Location of discharge and sampling points.



Source: Natural Resources Wales

The data provided covered the period 5 January 2017 to 16 December 2021. Samples with indicated caveats were excluded, as they indicate sampling and methodology error and may not represent the routine quality of the River Dee. No data were available for aluminium or total suspended solids.

Daily data from a flow gauge approximately 15 km upstream of the discharge point on the River Dee at Manley Hall (ID = 67015) were downloaded from the UK Centre for Ecology and Hydrology website and used to calculate the upstream average and Q95. The most recent five-year period of data was used, from 1 October 2015 to 30 September 2020.

Statistical analysis of the water quality data provided the mean and standard deviation for each determinand (Table 2.1). Any 'less than' values were halved in accordance with the EA Codes of Practice for Data Handling (Ellis *et al*., 1993).

Table 2.1 River flow and quality in the River Dee upstream of the discharge

Determinand	Upstream river conditions			
	Mean (mg/l)	SD (mg/l)	Q95 (flow only)	Source
Flow	33.6 (m^3/s)	33.1 (m^3/s)	8.8 (m^3/s)	Manley Hall
BOD	1.4	0.3	n/a	Farndon Bridge*
Ammonia	0.016	0.012	n/a	Old Bangor Bridge
Phosphate	0.08	0.03	n/a	Farndon Bridge*
pH	8.1	0.4	n/a	Old Bangor Bridge
Temperature	10.6	4.2	n/a	Old Bangor Bridge

*No data available at Old Bangor Bridge upstream of the discharge so downstream site used instead.

Mean phosphate concentration has increased by 0.04 mg/l in the upstream river since the initial investigation in 2015 and is now non-compliant with the WFD Good Status. BOD and pH have also increased, with their mean concentration increasing from 1.0 to 1.4 mg/l and 7.7 to 8.1 mg/l respectively. Furthermore, river flow has generally increased from 32.0 to 33.6 m^3/s and 8.6 to 8.8 m^3/s for average and Q95 respectively.

2.2 Discharge flow and quality

Discharge quality parameters were defined by the existing concentrations permitted for the site, whilst current average and maximum daily discharge flows were increased in accordance with the proposed doubling of weekly throughput (Table 2.2). Maelor Foods determined the higher average discharge as the water used per bird (7 l) multiplied by the number of birds (2 million), and then divided by the number of operational days (6). To determine the higher maximum

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discharge, the maximum hourly discharge (130 m^3h^{-1}) was multiplied by the maximum operational hours in a day (24).

Table 2.2 Discharge limits applied in modelling

Determinand	Discharge limit	Units	Expressed as	Distribution applied in RQP	
				Mean (mg/l)	SD (mg/l)
Current Average daily flow	1,200	m^3/d	Mean	0.014 m^3/s	0.003 m^3/s
Current Maximum daily flow	1,500	m^3/d	Maximum	0.017 m^3/s	0 m^3/s
Proposed Average daily flow	2,400	m^3/d	Mean	0.03 m^3/s	0.006 m^3/s
Proposed Maximum daily flow	3,120	m^3/d	Maximum	0.04 m^3/s	0 m^3/s
BOD	20	mg/l	Maximum	10.0	3.3
Ammonia	5	mg/l	Maximum	2.5	0.8
Phosphate	2.5	mg/l	Maximum	1.3	0.4
pH	6 to 9	n/a	Minimum and maximum	7.5	1.3
Temperature	30	°C	Maximum	n/a	n/a

As the limits were all maxima, values were treated as upper tier limits (99^{th} percentile). Discharge quality is defined in the River Quality Planning (RQP) tool by a mean and standard deviation, which were calculated from the maximum values assuming a coefficient of variation (CofV) of 0.33. A CofV of 0.2 was used for average discharge daily flow, as limited variation was assumed.

2.3 River quality standards

NRW provided details of the High and Good physico-chemical Environmental Quality Standards (EQS) at two sites:

1. ID 87 – River Dee at Old Bangor Bridge. This is located immediately upstream of the discharge. Grid Ref SJ 38780 45439

2. ID 671 – River Dee at Farndon Bridge. This is located downstream of the discharge point (Figure 2.1). Grid Ref SJ 4117054370

The High and Good river quality standards at site 671 are shown in Table 2.3. The High standard from 671 was used in the modelling, as this is downstream and therefore affected by the discharge.

Table 2.3 Physico-chemical EQS at site 671, River Dee at Farndon Bridge

Determinand	EQS expressed as[1]	High Standard	Good Standard
BOD	90th percentile	3 mg/l	4 mg/l
Ammonia	90th percentile	0.3 mg/l	0.6 mg/l
Phosphate	Mean	0.028 mg/l	0.054 mg/l
pH	n/a	6.6	5.95
Temperature	Maximum	20°C	23°C

2.4 Methodology

2.4.1 River Quality Planning Monte Carlo modelling

The EA's River Quality Planning Monte Carlo modelling tool was used to determine the impact of the increased effluent discharge to the River Dee for four determinands:

- BOD
- Ammonia
- Phosphate
- pH

Observed aluminium and total suspended solid data were not available for the River Dee and iron was not included in the permit. Therefore, these determinands were not included in the modelling.

The following assumptions were applied to the modelling:

1. Upstream river concentrations were based on summary statistics from the observed data provided by NRW, as outlined in section 2.1.

[1] The 90th percentile (or 90%ile) is the value for which 90% of the data points are smaller. It is a value from a statistical distribution.

2. Discharge concentrations were based on summary statistics calculated from the maxima issued within the site's current permit, as outlined in section 2.2.

3. Mixing between effluent flow and river flow occurs instantaneously at the point of discharge.

4. All determinands have a maximum consent; pH also has a minimum limit.

2.4.2 Temperature modelling

The Maelor Foods discharge is at a higher temperature than the ambient temperatures of the River Dee. Modelling was required to identify by how much the downstream temperature would change compared to the upstream temperatures under a higher discharge flow.

The modelling was completed using WRc's in-house mass and energy balance spreadsheet tool, which assumes that the mixing between effluent and river waters occurs instantaneously. It does not include any representation of cooling through heat losses to the atmosphere, and therefore provides a conservative estimate of the temperature rise.

Results were calculated on a monthly average basis, with the observed temperature data from monitoring site 87 (River Dee at Old Bangor Bridge) and observed monthly river flow data from the upstream flow gauge at Manley Hall (Table 4). The temperature record for site 87 was incomplete, with data only available for 7 months. Furthermore, some months only had one data point, reducing confidence in the temperature record. Data were supplemented from the previous 2015 analysis for the 5 months missing data, as well as for May, which appeared to be a single anomalous result when compared to the trend seen downstream and in 2015. The discharge was modelled for a constant discharge flow of 2,400 m^3/d and 3,120 m^3/d, both at a constant temperature of 30.0°C.

Table 2.4 Mean monthly temperature and flow in the River Dee upstream of discharge

Month	Mean monthly river temperature (°C)	Monthly River flow (m^3/s)	
		Mean	Q95
January	5.0*	46.5	13.2
February	4.7*	57.4	14.5
March	7.3	46.8	12.7
April	9.9*	23.8	8.3
May	11.5*	12.3	8.3
June	14.7	19.7	8.7

Month	Mean monthly river temperature (°C)	Monthly River flow (m^3/s)	
		Mean	Q95
July	17.4*	14.4	8.7
August	17.1	20.6	9.1
September	13.7	24.2	9.4
October	11.6*	33.6	8.7
November	10.2	42.6	10.9
December	6.7	62.4	15.9

* Data from 2015 analysis

3. River Quality Planning tool results

3.1 Receiving water impact based on current discharge regime

3.1.1 Current average discharge – 1,200 m^3/d

The modelled impact of the current average discharge of 1,200 m^3/d, (equivalent to a mean of 0.014 m^3/s and a standard deviation of 0.003 m^3/s), with discharge quality based on the site's current permit, is summarised in Table 3.1.

Table 3.1 Summary of the River Quality Planning Monte Carlo modelling – current average discharge flow

Determinand	Observed upstream river concentration		Modelled discharge permit		Modelled downstream river concentration		% change in downstream river	
	Mean	90%ile (from RQP)	Limit	Type	Mean	90%ile	Mean	90%ile
BOD	1.4	1.8	20 mg/l	Maximum	1.4	1.8	0.0	0.0
Ammonia	0.016	0.031	5 mg/l	Maximum	0.021	0.034	31.3	9.7
Phosphate	0.083	0.12	2.5 mg/l	Maximum	0.084	0.12	1.2	0.0
pH	8.1	8.6	6-9	Range	8.1	8.6	0.0	0.0

The current average discharge has the following predicted modelled impacts:

- An increase of approximately 30% is predicted for the mean ammonia concentration downstream, with an approximate 10% increase in the 90th percentile. This is due to an increase of 0.005 mg/l and 0.003 mg/l in the mean and 90th percentile concentrations respectively. Because the river upstream has a low ammonia concentration, a small absolute increase in the downstream concentration results in a large percentage difference.

- A small (1.2%) increase in mean phosphate is also predicted.

3.1.2 Current maximum discharge – 1,500 m^3/d

The modelled impact of a maximum discharge flow of 1,500 m^3/d (0.017 m^3/s), with discharge quality based on the site's current permit, is summarised in Table 3.2.

Table 3.2 Summary of the River Quality Planning Monte Carlo modelling – current maximum discharge flow

Determinand	Observed upstream river concentration		Modelled discharge permit		Modelled downstream river concentration		% change in downstream river	
	Mean	90%ile (from RQP)	Limit	Type	Mean	90%ile	Mean	90%ile
BOD	1.4	1.8	20 mg/l	Maximum	1.4	1.8	0.0	0.0
Ammonia	0.016	0.031	5 mg/l	Maximum	0.022	0.035	37.5	12.9
Phosphate	0.083	0.12	2.5 mg/l	Maximum	0.084	0.12	1.2	0.0
pH	8.1	8.6	6-9	Range	8.1	8.6	0.0	0.0

The modelled results at the current maximum discharge show that:

- An increase of approximately 38% is predicted for the mean ammonia concentration in the river downstream, with an approximate 13% increase in the 90th percentile. As with current average discharge flow, this is due to small 0.006 mg/l and 0.004 mg/l increases in the mean and 90th percentile respectively.

- As with the average discharge, a small (1.2%) increase in mean phosphate is also predicted.

- BOD and pH are unaffected.

3.2 Receiving water impact based on proposed increased discharge regime

3.2.1 Proposed average discharge – 2,400 m^3/d

The modelled impact of an average discharge flow of 2,400 m^3/d, with discharge quality based on the site's current permit, is summarised in Table 3.3.

Table 3.3 Summary of the River Quality Planning Monte Carlo modelling – proposed average discharge flow

Determinand	Observed upstream river concentration		Modelled discharge permit		Modelled downstream river concentration		% change in downstream river	
	Mean	90%ile (from RQP)	Limit	Type	Mean	90%ile	Mean	90%ile
BOD	1.4	1.8	20 mg/l	Maximum	1.4	1.8	0.0	0.0
Ammonia	0.016	0.031	5 mg/l	Maximum	0.019	0.035	18.8	12.9
Phosphate	0.083	0.12	2.5 mg/l	Maximum	0.084	0.12	1.2	0.0
pH	8.1	8.6	6-9	Range	8.1	8.6	0.0	0.0

The proposed increase in the average discharge flow to 2,400 m^3/d has the following impacts:

- The additional ammonia load increases the ammonia concentration in the river downstream by approximately 19% and 13% at the mean and 90%ile respectively. The upstream river has a low ammonia concentration, therefore a small absolute change in the downstream concentration results in a large percentage difference.
- BOD and pH are unaffected
- Mean phosphate increases by 1.2% downstream but the 90^{th} percentile in unchanged.
- BOD and ammonia concentrations downstream remain at WFD High Status. Despite these increases, all values excluding phosphate are within the NRW High and Good river standards.

3.2.2 Proposed maximum discharge – 3,120 m^3/d

The modelled impact of a maximum discharge flow of 3,120 m^3/d, with discharge quality based on the site's current permit, is summarised in Table 3.4.

Table 3.4 Summary of the River Quality Planning Monte Carlo modelling – proposed maximum discharge flow

Determinand	Observed upstream river concentration		Modelled discharge permit		Modelled downstream river concentration		% change in downstream river	
	Mean	90%ile (from RQP)	Limit	Type	Mean	90%ile	Mean	90%ile
BOD	1.4	1.8	20 mg/l	Maximum	1.4	1.8	0.0	0.0
Ammonia	0.016	0.031	5 mg/l	Maximum	0.021	0.037	31.3	19.4
Phosphate	0.083	0.12	2.5 mg/l	Maximum	0.085	0.12	2.4	0.0
pH	8.1	8.6	6.6	Minimum	8.1	8.6	0.0	0.0

The proposed increase in the maximum discharge flow to 3,120 m^3/d has the following impacts:

- The additional ammonia load increases the ammonia concentration in the river downstream by approximately 31% and 19% at the mean and 90%ile respectively. This is due to a small absolute increase in the downstream concentration of 0.006 mg/l causing a large percentage difference.
- BOD and pH are unaffected.
- Mean phosphate increases by 2.4% downstream but the 90th percentile in unchanged.
- BOD and ammonia concentrations downstream remain at WFD High Status. Despite these increases, all values excluding phosphate are within the NRW High and Good river standards.
- As stated in Section 2.1, upstream phosphate concentration has increased upstream since the 2015 analysis and is now non-compliant with WFD Good Status.

3.3 Comparison between current and proposed discharge regime

The proposed increase in average operational discharge (from 1,200 m^3/d to 2,400 m^3/d) is predicted to increase the downstream 90%ile ammonia by 12.9% (0.004 mg/l).

The proposed increase in the maximum discharge (from 1,500 m^3/d to 3,120 m^3/d) is predicted to increase downstream 90%ile ammonia by 19.4% (0.006 mg/l).

There is a 1.2% increase in mean phosphate (0.083 to 0.084 mg/l) for average discharge and a 2.4% increase in mean phosphate (0.083 to 0.085 mg/l) for maximum discharge.

4. Monthly temperature modelling results

4.1 Monthly average river flows

The temperature modelling showed that the predicted impact on the river temperature downstream for both the average discharge flow of 2,400 m^3/d and the maximum flow of 3,120 m^3/d at 30.0°C is small, with differences only at the second decimal place (Table 4.1).

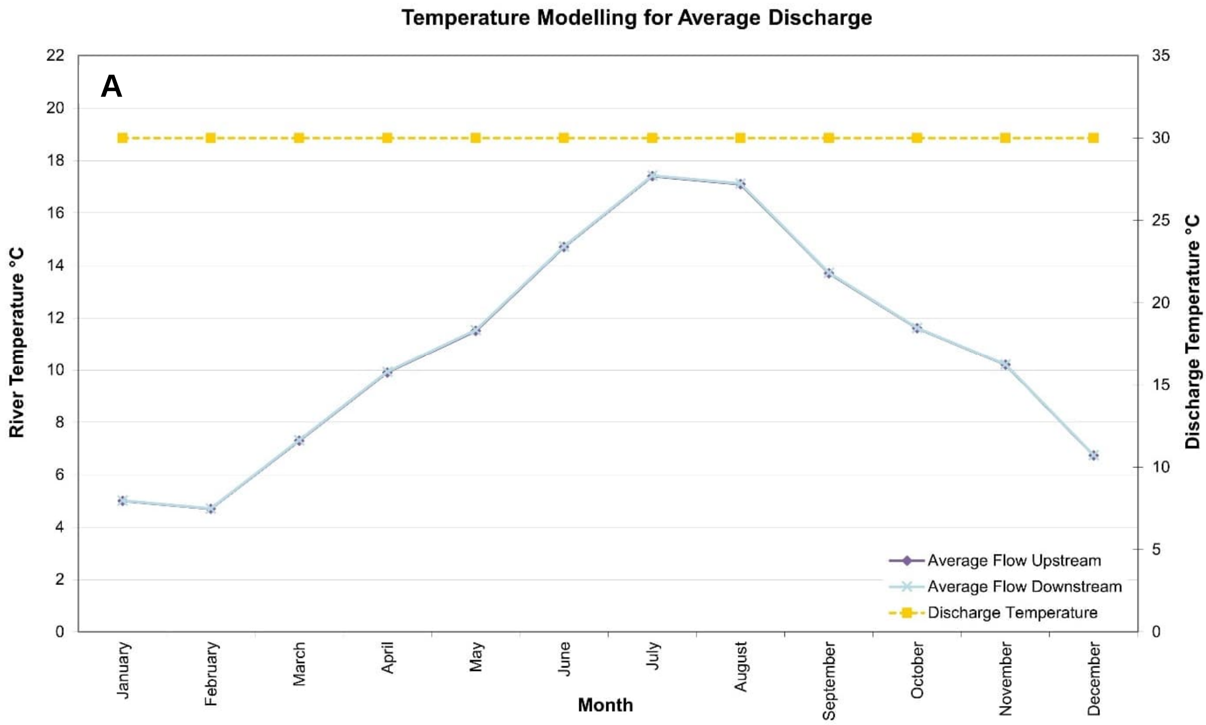
The temperature modelling assumes that the discharge is instantaneously mixed within the river. The results are illustrated in Figure 4.1 and show the monthly temperatures of the discharge and the river upstream and downstream of the discharge. Graph A shows the results simulating the average discharge flows and Graph B shows the results of the maximum discharge flows. The predicted increase is small in both cases, and the resultant series are almost co-incident on the graph illustrating the negligible effect on river temperature.

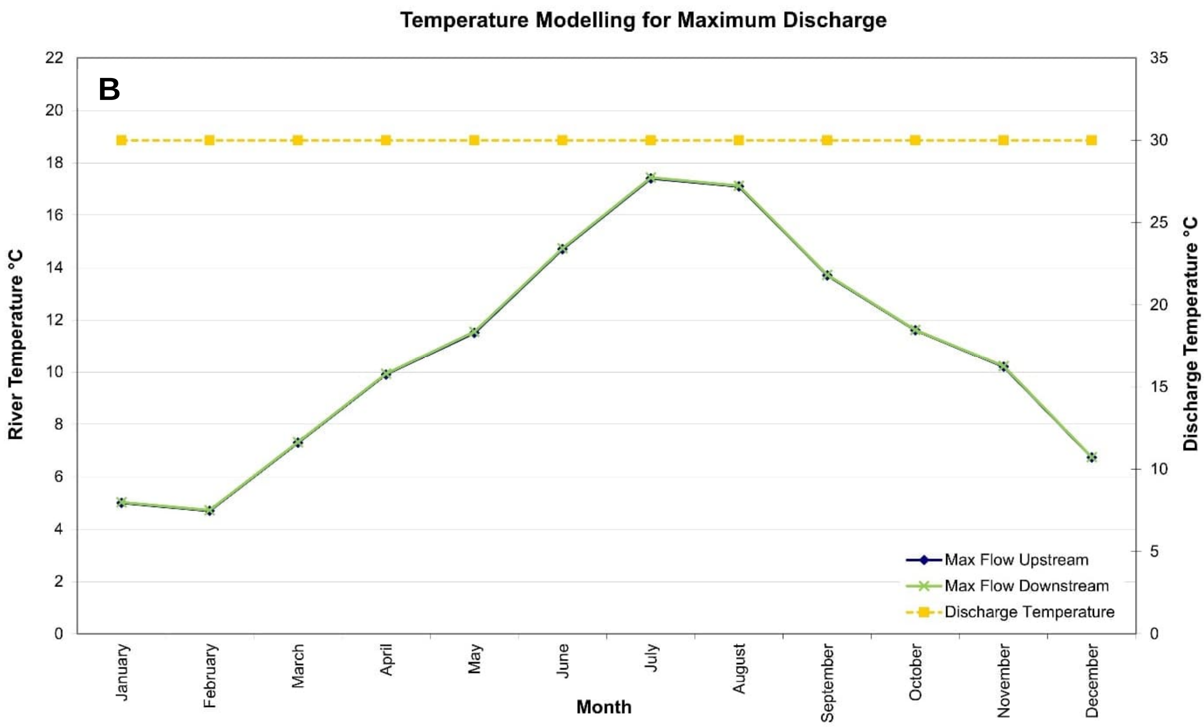
Table 4.1 Summary of the impact of the proposed discharge on temperature in the River Dee – average and maximum river flow

Month	Temperature (°C)				
	Upstream	Average discharge flow (2,400 m^3/d)		Maximum discharge flow (3,120 m^3/d)	
		Downstream	Differential	Downstream	Differential
January	5.0*	5.0	0.015	5.0	0.019
February	4.7*	4.7	0.012	4.7	0.016
March	7.3	7.3	0.013	7.3	0.017
April	9.9*	9.9	0.023	9.9	0.031
May	11.5*	11.5	0.042	11.6	0.054
June	14.7	14.7	0.022	14.7	0.028
July	17.4*	17.4	0.024	17.4	0.031
August	17.1	17.1	0.017	17.1	0.023
September	13.7	13.7	0.019	13.7	0.024
October	11.6*	11.6	0.015	11.6	0.020
November	10.2	10.2	0.013	10.2	0.017
December	6.7	6.7	0.010	6.7	0.013

* Data from 2015 analysis

Figure 4.1 Comparison of mean monthly upstream and downstream river temperature profiles





4.2 Monthly Q95 river flows

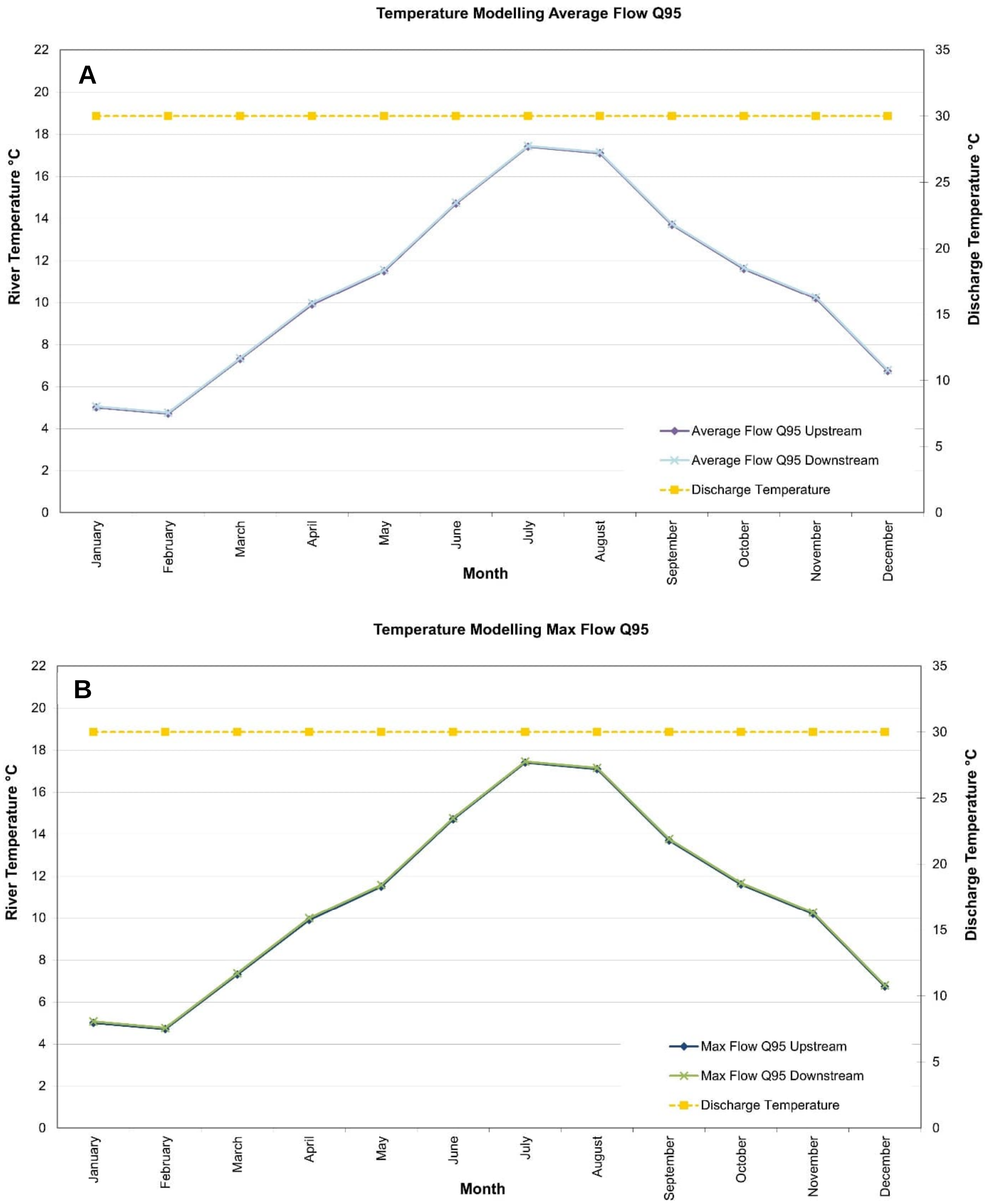
The modelling also examined the effect on low river flows, the Q95 or 5%ile flow. The results showed that the predicted impact on the downstream river temperature from the average and maximum discharge flow is small (Table 4.2). Increases in the downstream river temperature were predicted at only the second decimal place. The results are illustrated in Figure 4.2 and show that the effect of both average (Plot A) and maximum (Plot B) discharges when the flow in the river is low (Q95) is negligible.

Table 4.2 Summary of the impact of the proposed discharge on temperature in the River Dee – Q95 river flow

Month	Temperature (°C)				
	Upstream	Average discharge flow		Maximum discharge flow	
		Downstream	Differential	Downstream	Differential
January	5.0*	5.1	0.052	5.1	0.068
February	4.7*	4.7	0.048	4.8	0.063
March	7.3	7.3	0.050	7.4	0.065
April	9.9*	9.9	0.067	10.0	0.087
May	11.5*	11.5	0.062	11.6	0.080
June	14.7	14.7	0.049	14.8	0.063
July	17.4*	17.4	0.040	17.5	0.052
August	17.1	17.1	0.039	17.2	0.051
September	13.7	13.7	0.048	13.8	0.062
October	11.6*	11.6	0.059	11.7	0.076
November	10.2	10.2	0.050	10.3	0.066
December	6.7	6.7	0.041	6.8	0.053

* Data from 2015 analysis

Figure 4.2 Comparison of modelled changes in downstream river temperature profiles compared to upstream at 30.0°C – Q95 monthly river flows



4.3 Summary

The temperature modelling showed that the proposed increased discharges of 2,400 m^3/d and 3,120 m^3/d at a temperature of 30 °C would not increase the river temperature under average or Q95 river flow conditions.

It should be noted that the modelling assumes that the discharge and river flows are fully mixed across the river at the point of discharge. In reality, the discharge is unlikely to be fully mixed until further downstream, with the effluent plume possibly hugging one side of the river. This is likely to result in higher temperature differential than described, especially closer to the discharge.

5. Conclusions

A water quality modelling assessment has been carried out for a proposed doubling of discharge flow by Maelor Foods Ltd to the River Dee in Wrexham. The assessment used the Environment Agency's River Quality Planning (RQP) Monte Carlo tool to model the effect of the discharge on the downstream river quality, specifically for determinands: BOD, ammonia, total phosphate, and pH. A mass balance spreadsheet tool was used to model the resultant river temperature downstream of the discharge.

The results were based on proposed discharge flows of an average 2,400 m^3/d and a maximum 3,120 m^3/d, with quality based on the discharge concentrations currently permitted at the site. The results showed that the predicted impact of the discharge on downstream river quality is:

- Generally small, with most quality determinands showing little change from that predicted for the current permitted discharge flow.

- An approximate 13% increase in ammonia was predicted in the river downstream under increased average discharge flow, whilst an approximate 20% increase in ammonia was predicted for the river under increased maximum discharge flow. These relate to small 0.004 and 0.006 mg/l increases in the 90%ileunder increased average and maximum discharge flows respectively.

- BOD and pH showed no increase at the 90%ile for both the proposed increased average and maximum discharge flows.

- Mean phosphate showed a 1.2% and 2.4% increase in the river for the average and maximum discharge flows respectively.

This was also reflected in the monthly temperature modelling, which showed no increase in temperature except at the second decimal place under Q95 (low) flow and average flow conditions in the river, however, the simple spreadsheet tool assumes full and instantaneous mixing whereas in relative the temperature will be higher closer to the discharge.

6. References

Ellis, J.C., van Dijk, P.A.H. and Kinley, R.D. (1993) Codes of Practice for Data Handling. NRA Report No. R&D 241.

Appendix A Detailed results from RQP

Maelor Foods - RQP Analysis Outputs.xlsx contains the RQP modelling inputs and results and has been provided electronically as an appendix to this report.