Appendix 9



Maelor Foods Wrexham - Proposed Increased Discharge Impact Assessment - Final Report

Report Reference: UC16765 v3
March 2023

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Maelor Foods Wrexham - Proposed Increased Discharge Impact Assessment - Final Report

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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, orthophosphate, iron, chloride, and pH. A mass balance spreadsheet tool was used to model the resultant river temperature downstream of the discharge.

The assessment results were based on proposed discharge flows of an average 2,400 m^3/d and a maximum 3,120 m^3/d, with discharge quality based on the concentrations expected with additional tertiary treatment in place at the site.

The river quality assessment showed that the predicted impact of increased discharge, that had undergone tertiary treatment, was small, with a <4% decrease predicted in downstream BOD, ammonia, and orthophosphate concentrations when compared to the current discharge. Downstream mean iron and chloride concentrations increased by 2.6% and 8.5% respectively. No change was observed in pH. Modelled downstream river concentrations for the seven determinands assessed were lower than the face value of the relevant river standard.

The monthly temperature modelling showed a very small increase (to the second decimal place) in river temperature for the current and proposed discharges, under both average and Q95 (low) flow conditions in the river.

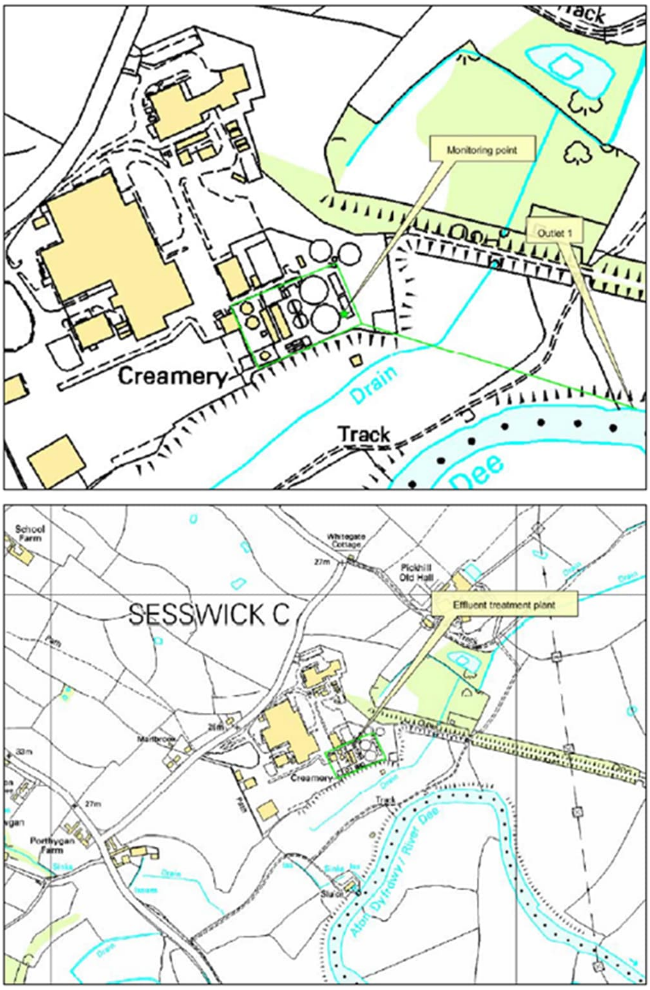
The assessment results show a slight improvement in river quality for BOD, ammonia, and orthophosphate downstream of the proposed increased when compared to the impact of the current discharge on the river.

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 capacity of 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 2023, WRc was again commissioned to undertake a modelling assessment for a proposed doubling in discharge. The same methodology was used to assess the water quality impact of the current and proposed increased discharge on the River Dee. The upstream river flow and water quality information was based on the latest observed data.

1.2 Determinands

The assessment was required for the following determinands:

- BOD
- Total suspended solids
- Ammonia
- Orthophosphate
- Iron
- Chloride
- Temperature
- pH

1.3 Modelling tool

The Environment Agency's (EA) RQP tool is part of the required methodology for the assessment of discharges to inland surface waters.

The discharge is above ambient temperature and its effect on the River Dee was assessed using a spreadsheet tool developed by WRc, to allow the seasonal variation (monthly) in river temperature to be represented. It is not possible to do this in RQP.

2. Data and Methodology

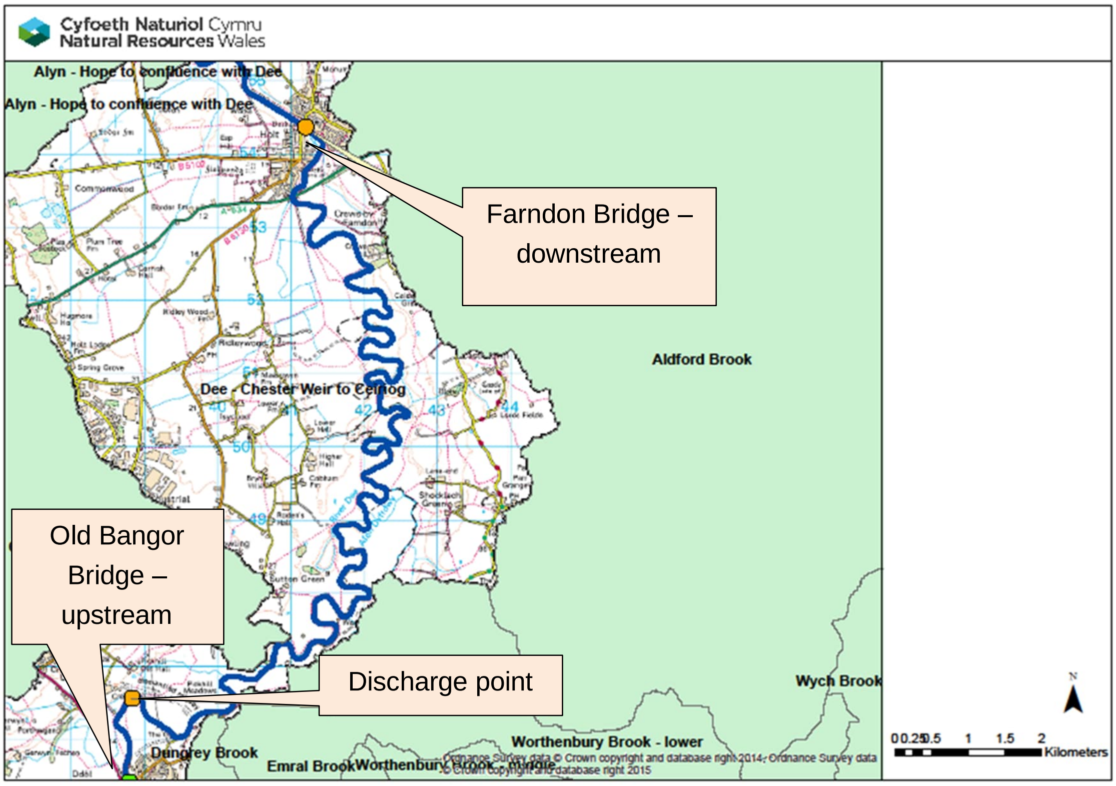
2.1 Upstream river flow and quality

Monthly data for the river quality upstream and downstream of the proposed discharge were supplied by Natural Resources Wales (NRW) (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 covered the period 3 January 2018 to 14 December 2022. Samples with caveats were excluded, as they indicated sampling and/or methodology errors 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 2016 to 30 September 2021.

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	SD	Source
Flow (m^3/s)	33.06	8.91 (Q95)	Manley Hall Flow Gauge
BOD (mg/l)	1.35	0.21	Farndon Bridge*
Ammonia (mg/l)	0.016	0.012	Old Bangor Bridge
Orthophosphate (mg/l)	0.013	0.011	Old Bangor Bridge
pH	8.10	0.31	Old Bangor Bridge
Temperature (°C)	10.6	4.2	Old Bangor Bridge

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

River quality is similar to 2015. River flow has increased from 32.0 to 33.1 m^3/s and 8.6 to 8.9 m^3/s for mean and Q95 respectively, pH has increased from 7.7 to 8.1.

2.2 Discharge flow and quality

The discharge flow and quality characteristics used as inputs to the river impact assessment to define the current and proposed discharge regimes are shown in Table 2.2 for the current permitted conditions and in Table 2.3 for the proposed increased flow and upgraded quality discharge.

Table 2.2 Current discharge flow and quality permit limits applied in modelling

Determinand	Discharge limit	Units	Permit limits 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
BOD	20	mg/l	Maximum	9.97	3.29
Ammonia	5	mg/l	Maximum	2.49	0.82
Orthophosphate	2.5	mg/l	Maximum	1.25	0.41
pH	6 to 9	n/a	Minimum and maximum	7.50	1.29
Iron	-	mg/l	-	0.862	0
Chloride	-	mg/l	-	841	0
Temperature	30	°C	Maximum	n/a	n/a

Note: There are no permitted limits for iron and chloride, therefore the modelled concentrations were derived from laboratory analysis of effluent. These are based on one sample.

Table 2.3 Proposed discharge flow and quality limits applied in modelling

Determinand	Discharge limit	Units	Discharge limits expressed as	Distribution applied in RQP	
				Mean (mg/l)	SD (mg/l)
Proposed average daily flow	2,400	m^3/d	Mean	0.028 m^3/s	0.006 m^3/s
Proposed maximum daily flow	3,120	m^3/d	Maximum	0.036 m^3/s	0 m^3/s
BOD	10	mg/l	Maximum	4.98	1.64
Ammonia	2	mg/l	Maximum	1.00	0.33
Orthophosphate	1	mg/l	Maximum	0.50	0.16
pH	6 to 9	n/a	Minimum and maximum	7.50	1.29
Iron	-	mg/l	-	0.862	0
Chloride	-	mg/l	-	841	0
Temperature	30	°C	Maximum	n/a	n/a

Note: There are no permitted limits for iron and chloride, therefore the modelled concentrations were derived from laboratory analysis of effluent. These are based on one sample.

Discharge quality and flow is represented in the RQP tool by a statistical distribution defined by a mean and standard deviation, or Q95 for flow. The distributions for the discharge quality parameters were calculated from the permit limits maximum values, which were taken to be 99%iles rather than 100%iles (maximum), to facilitate this calculation, and an assumed Coefficient of Variation (CoV) of 0.33. A lower CoV of 0.2 was used to calculate the distribution of average discharge daily flow to give a limited variation in flow.

It should be noted that the values applied in RQP for iron and chloride were based on a single effluent sample.

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

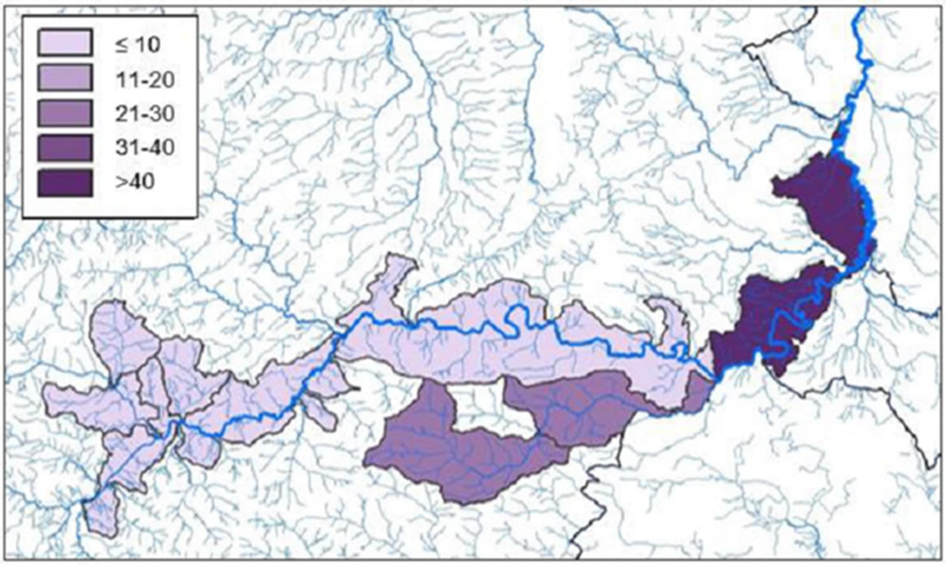
The High and Good Status WFD river quality standards at site 671 are shown in Table 2.4.

An additional standard for orthophosphate is relevant for parts of the River Dee in relation to the River Dee & Llyn Tegid SAC. Figure 2.2 shows a map of orthophosphate targets for the River Dee & Llyn Tegid SAC and the location of the Maelor Foods discharge. This shows the orthophosphate concentration target for the river at the discharge point is >40 µg/l. The target is 50 µg/l.

Table 2.4 Physico-chemical EQS at site 671, River Dee at Farndon Bridge and for orthophosphate in the River Dee & Llyn Tegid SAC

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
Orthophosphate (WFD standard)	Mean	0.028 mg/l	0.054 mg/l
Orthophosphate (SAC standard)	Mean	50 µg/l	
pH	Range	6 (5%ile) to 9 (95%ile)	5.2 (10%ile)
Temperature	Maximum	20°C	23°C
Iron[2]	Mean	1000 mg/l	
Chloride[2]	Mean	250 mg/l	

Figure 2.2 Orthophosphate Targets for River Dee & Lyn Tegid SAC (Hatton-Lewis *et al.*, 2021)



All concentrations are annual means and growing season means in µg/l.

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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 An annual average freshwater EQS for iron (dissolved) and chloride as a specific pollutant for use in surface water risk assessment for permit applications (https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit).

Figure 2.3 shows the Chester Weir to Ceiriog stretch of the River Dee, the location of the Maelor Foods discharge and NRW's upstream and downstream river monitoring points:

- Site 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

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

Figure 2.3 Maelor Foods discharge point and river monitoring points upstream & downstream

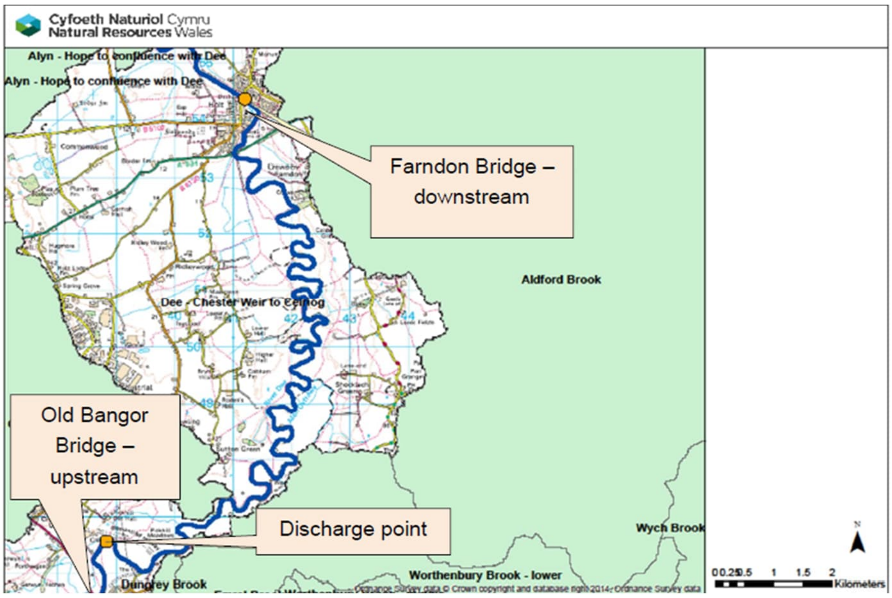


Figure 2.4 shows an extract of Table 2, page 28 of NRW's report "Compliance Assessment of Welsh River SACs against Phosphorus Targets" (Hatton-Lewis *et al.,* 2021) which shows results of river water monitoring undertaken over 3 years (2017 – 2019).

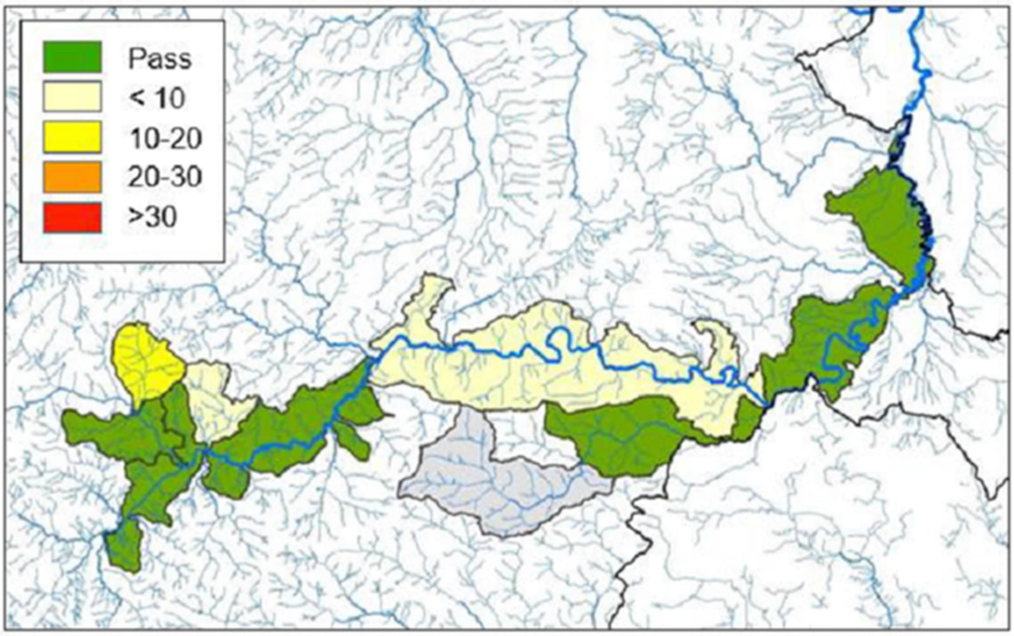
Figure 2.4 Results of River Dee water monitoring undertaken over 3 years (2017 – 2019)

Waterbody ID	Waterbody Name	Site	Target (µg l^{-1})	N Samples	Annual Mean (µg l^{-1})	Growing Season Mean (µg l^{-1})	Result	Status
GB111067051990	Mynach	300	10	19	25	27	Fail	Confirmed
GB111067051900	Tryweryn - Dee to Mynach	294	10	25	10	4	Pass	-
GB111067051960	Meloch	496	10	19	20	9	Fail	Unconfirmed
GB111067052240	Dee - Alwen to Llyn Tegid/ Bala Lake	1	10	27	7	4	Pass	-
GB111067052060	Dee - Ceiriog to Alwen	70	10	31	15	16	Fail	Confirmed
GB111067051610	Ceiriog - upstream of Teirw	-	28	No data			Not Assessed	-
GB111067051910	Ceiriog - confluence Dee to Teirw	578	28	31	22	26	Pass	-
GB111067057080	Dee - Chester Weir to Ceiriog	87, 671, 689	50	60	15, 50, 47	17, 46, 49	Pass	-

Table 2. Phosphorus Compliance for the River Dee SAC. All orthophosphate concentrations are in µg l^{-1}.

Figure 2.5 shows the phosphorus compliance map for the River Dee SAC (Hatton-Lewis *et al.,* 2021). Water bodies shaded green pass their target. Other colours fail the target with different colours representing the magnitude of failures, units are µg/l, expressed as the larger of annual means and growing season means. Figure 2.5 shows that for the period 2017-2019 the Chester Weir to Ceiriog stretch of the River Dee, which receives the discharge from Maelor Foods, was compliant with the SAC orthophosphate target of 50 µg/l.

Figure 2.5 Phosphorus compliance map for the River Dee SAC



2.4 Assessment Methodology

2.4.1 River Quality Planning (RQP) Monte Carlo modelling

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

- BOD
- Ammonia
- Orthophosphate
- pH
- Iron
- Chloride

Total suspended solid data were not available for the River Dee and therefore could not be included in the modelling.

The following information and assumptions were made for the assessment modelling:

1. Upstream river quality was defined by summary statistics calculated from the observed data provided by NRW, as outlined in Table 2.1 (Section 2.1).

2. Discharge quality was based on summary statistics calculated from the site's current permit and proposed performance, as outlined in Table 2.2 and Table 2.3 (Section 2.2).

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

4. Discharge permit limits are defined as either mean (flow), minimum (pH) or maximum.

2.4.2 Temperature modelling

The Maelor Foods discharge is at a higher temperature than the ambient temperature of the River Dee. A different modelling approach was required to identify the impact of the proposed increased discharge on the downstream temperature.

The modelling was undertaken using WRc's in-house temperature balance spreadsheet tool. This assumes that 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 using data from 2017 to 2021, with the observed temperature data from the upstream monitoring site 87 (River Dee at Old Bangor Bridge) and observed monthly river flow data from the upstream flow gauge at Manley Hall (Table 2.5). The temperature record for the upstream site (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 therefore supplemented from the previous 2015 analysis for the 5 months missing data, as well as for May, which appeared to be anomalous when compared to the temperature 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, and a constant temperature of 30.0°C which is the maximum permit limit.

Table 2.5 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
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, with discharge quality based on the site's current permit, is summarised in Table 3.1.

Table 3.1 Assessment results for the current average discharge flow (1,200 m^3/d)

Determinand	Observed upstream river concentration		Modelled discharge permit		Modelled downstream river concentration		% change in river from upstream		River standards[3]	
	Mean	90%ile	Limit	Type	Mean	90%ile	Mean	90%ile	Mean	90%ile
BOD (mg/l)	1.35	1.62	20	Max	1.36	1.63	0.9	0.6	-	3[4]
Ammonia (mg/l)	0.015	0.029	5	Max	0.016	0.031	3.5	6.9	-	0.3[4]
Orthophosphate (µg/l)	13.0	24.9	2500	Max	13.7	25.9	5.4	4.0	54[5] (WFD) 50 (SAC)	-
pH	8.10	8.49	6 to 9	Range	8.10	8.49	0	0	6 to 9[4]	
Iron (mg/l)	0.156	0.230	-	-	0.160	0.230	2.6	0	1000	-
Chloride (mg/l)	11.7	17.0	-	-	12.2	17.7	4.3	4.1	250	-

The assessment results for the current permitted discharge at average flow shows that:

- Small (<1%) increases are observed in the mean and 90 percentile downstream BOD concentration compared with upstream.

[3] See Table 2.4 for the river quality standards.

[4] WFD High status.

[5] WFD Good status.

- A very small (0.001 mg/l) increase is predicted for mean ammonia concentration, with a 0.002 mg/l increase at the 90 percentile. This corresponds to a 3.5% and 6.9% increase downstream respectively compared to upstream.

- A small (0.7 µg/l) increase is predicted for downstream mean orthophosphate concentration, with a 1 µg/l increase at the 90 percentile. This corresponds to a 5.4% and 4% increase downstream respectively.

- A small (<5%) increase is predicted for iron and chloride concentration downstream.

- pH is unaffected.

The assessment shows that the predicted river concentrations downstream are lower than the face value of the relevant river standard, i.e. are compliant with the river quality targets.

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, with discharge quality based on the site's current permit, is summarised in Table 3.2.

Table 3.2 Assessment results for the current maximum discharge flow (1,500 m^3/d)

Determinand	Observed upstream river concentration		Modelled discharge permit		Modelled downstream river concentration		% change in river from upstream		River standards[6]	
	Mean	90%ile	Limit	Type	Mean	90%ile	Mean	90%ile	Mean	90%ile
BOD (mg/l)	1.35	1.62	20	Max	1.36	1.63	0.9	0.6	-	3
Ammonia (mg/l)	0.015	0.029	5	Max	0.017	0.032	9.9	10.3	-	0.3
Orthophosphate (µg/l)	13.0	24.9	2500	Max	14.0	26.3	7.7	5.6	54 (WFD) 50 (SAC)	-
pH	8.10	8.49	6 to 9	Range	8.10	8.49	0	0	6 to 9	
Iron (mg/l)	0.156	0.230	-	-	0.160	0.230	2.6	0	1000	-
Chloride (mg/l)	11.7	17.0	-	-	12.2	17.7	4.3	4.1	250	-

[6] See Table 2.4 for the river quality standards.

The assessment results for the current permitted discharge at maximum flow shows that:

- Small (<1%) increases are observed in the mean and 90 percentile downstream BOD concentration compared to upstream.

- A small (0.002 mg/l) increase is predicted in the downstream mean ammonia concentration, with an increase of 0.003 mg/l at the 90 percentile. However, this corresponds to a 9.9% and 10.3% increase downstream respectively, due to the low concentration of ammonia in the river.

- A 1 µg/l increase is predicted for mean orthophosphate concentration, with a 1.4 µg/l increase at the 90 percentile. This corresponds to a 7.7% and 5.6% downstream increase respectively.

- A small (<5%) increase is predicted for iron and chloride concentration downstream.

- pH is unaffected.

The assessment shows that the predicted river concentrations downstream are lower than the face value of the relevant river standard, i.e. are compliant with the river quality targets.

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 proposed performance, is summarised in Table 3.3.

Table 3.3 Assessment results for the proposed average discharge flow (2,400 m^3/d)

Determinand	Observed upstream river concentration		Modelled discharge permit		Modelled downstream river concentration		% change in river from upstream		River standards[7]	
	Mean	90%ile	Limit	Type	Mean	90%ile	Mean	90%ile	Mean	90%ile
BOD (mg/l)	1.35	1.62	10	Max	1.35	1.62	0.1	0.0	-	3
Ammonia (mg/l)	0.015	0.029	2	Max	0.016	0.03	3.5	3.4	-	0.3
Orthophosphate (µg/l)	13.0	24.9	1000	Max	13.6	25.7	4.6	3.2	54 (WFD) 50 (SAC)	-
pH	8.10	8.49	6 to 9	Range	8.10	8.49	0	0	6 to 9	
Iron (mg/l)	0.156	0.230	-	-	0.160	0.230	2.6	0	1000	-
Chloride (mg/l)	11.7	17.0	-	-	12.7	18.3	8.5	7.6	250	-

The assessment results for the proposed permitted discharge at average flow shows that:

- Small (<1%) increases are observed in the mean and 90 percentile downstream BOD concentration.

- A small (0.001 mg/l) increase is predicted for both the mean and 90 percentile ammonia concentration. This corresponds to a 3.5% and 3.4% downstream increase respectively.

- A 0.6 µg/l increase is predicted for mean orthophosphate concentration, with a 0.8 µg/l increase at the 90 percentile. This corresponds to a 4.6% and 3.2% downstream increase respectively.

- A small (2.6%) increase in mean iron is predicted.

- A 1 mg/l and 1.3 mg/l increase is predicted in the downstream mean and 90 percentile for chloride, equating to an 8.5% and 7.6% increase respectively.

- pH is unaffected.

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[7] See Table 2.4 for the river quality standards.

The assessment shows that the predicted river concentrations downstream are lower than the face value of the relevant river standard, i.e. are compliant with the river quality targets.

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 proposed performance, is summarised in Table 3.4.

Table 3.4 Assessment results for the proposed maximum discharge flow (3,120 m^3/d)

Determinand	Observed upstream river concentration		Modelled discharge permit		Modelled downstream river concentration		% change in river from upstream		River standards[8]	
	Mean	90%ile	Limit	Type	Mean	90%ile	Mean	90%ile	Mean	90%ile
BOD (mg/l)	1.35	1.62	10	Max	1.36	1.63	0.9	0.6	-	3
Ammonia (mg/l)	0.015	0.029	2	Max	0.017	0.031	9.9	6.9	-	0.3
Orthophosphate (µg/l)	13	24.9	1000	Max	13.8	26.0	6.2	4.4	54 (WFD) 50 (SAC)	-
pH	8.10	8.49	6 to 9	Range	8.10	8.49	0	0	6 to 9	
Iron (mg/l)	0.156	0.230	-	-	0.160	0.240	2.6	4.3	1000	-
Chloride (mg/l)	11.7	17.0	-	-	13.1	19.0	12.0	11.8	250	-

The assessment results for the proposed permitted discharge at maximum flow shows that:

- Small (<1%) increases are observed in the mean and 90 percentile downstream BOD concentration.
- A small (0.002 mg/l) increase is predicted for both the mean and 90 percentile ammonia concentration. This corresponds to a 9.9% and 6.9% downstream increase respectively.
- A 0.8 µg/l increase is predicted for mean orthophosphate concentration, with a 1.1 µg/l increase at the 90 percentile. This corresponds to a 6.2% and 4.4% downstream increase respectively.

[8] See Table 2.4 for the river quality standards.

- A small (<5%) increase in downstream mean and 90 percentile iron is predicted.
- A 1.4 mg/l and 2 mg/l increase is predicted in the downstream mean and 90 percentile for chloride, equating to an 12% and 11.8% increase respectively.
- pH is unaffected.

The assessment shows that the predicted river concentrations downstream are lower than the face value of the relevant river standard, i.e. are compliant with the river quality targets.

3.3 Comparison between current and proposed discharge regime

The predicted downstream impacts from the proposed higher discharge average and maximum flows were compared to that of the current average and maximum flows.

Table 3.5 Comparison between in downstream river quality for current permit and proposed discharge

Determinand	% change in downstream river quality compared to current permit			
	2,400 m³/d		3,120 m³/d	
	Mean	90%ile	Mean	90%ile
BOD	-0.7	-0.6	0	0
Ammonia	0	-3.2	0	-3.1
Orthophosphate	-1	-0.8	-1.4	-1.1
pH	0	0	0	0
Iron	0	0	0	4.3
Chloride	4.1	3.4	7.4	7.3

The assessment show that the proposed doubling of flow coupled with the anticipated improved treatment quality from the tertiary treatment, results in an improved river quality downstream compared to the current discharge. Small improvements are observed in the mean and 90 percentile of BOD, ammonia, and orthophosphate (<4% decrease in concentration). No change is seen in pH.

In-river chloride concentration is predicted to increase at both the mean and 90 percentile levels for the average and maximum proposed discharge. In-river iron concentration is predicted to increase at the 90 percentile for the maximum proposed discharge. Predicted concentrations remain below the stipulated river quality standards.

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 seen at the second decimal place (Table 4.1).

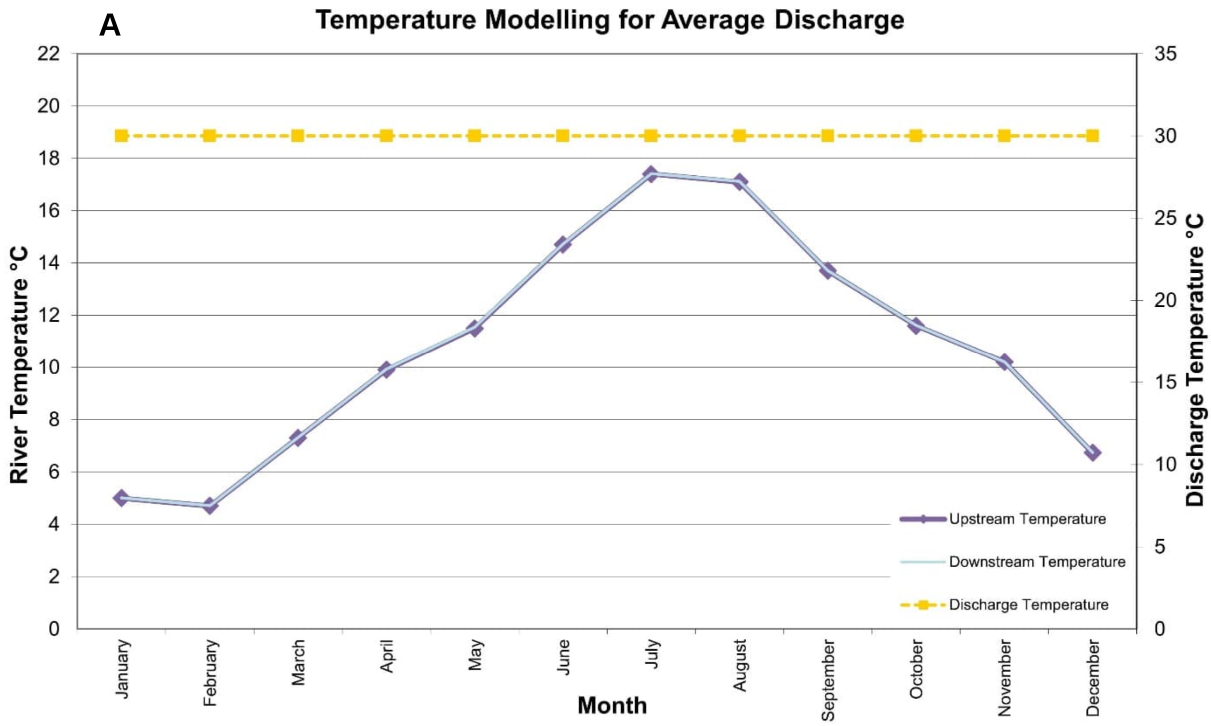
The temperature modelling assumes that the discharge is instantaneously mixed within the river. The results are illustrated in**Error! Reference source not found.** Figure 4.1 and show the monthly temperatures of the discharge and the river upstream and downstream of the discharge. Graph A shows the results of 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.

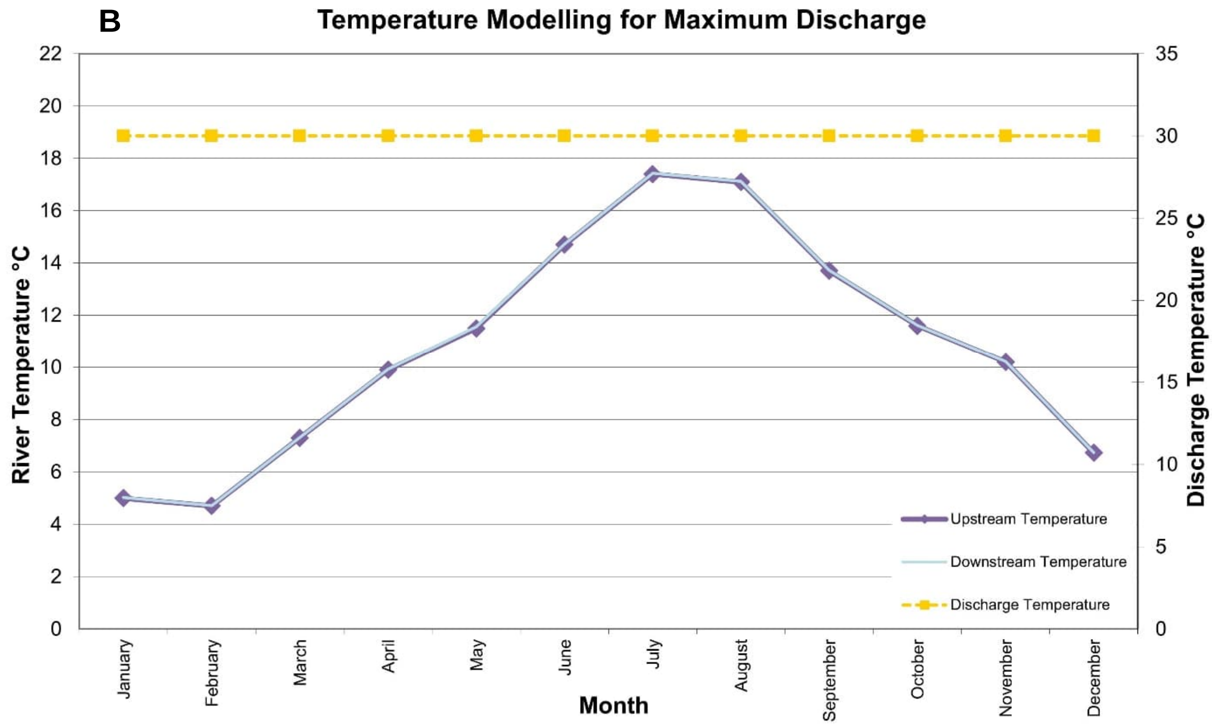
Table 4.1 Summary of the impact of the proposed discharge on temperature in the River Dee – average and maximum river flow

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 monthly upstream and downstream river temperature profiles for average river flows





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 (Graph A) and maximum (Graph B) discharges when the flow in the river is low (Q95) is negligible. **Error! Reference source not found.**

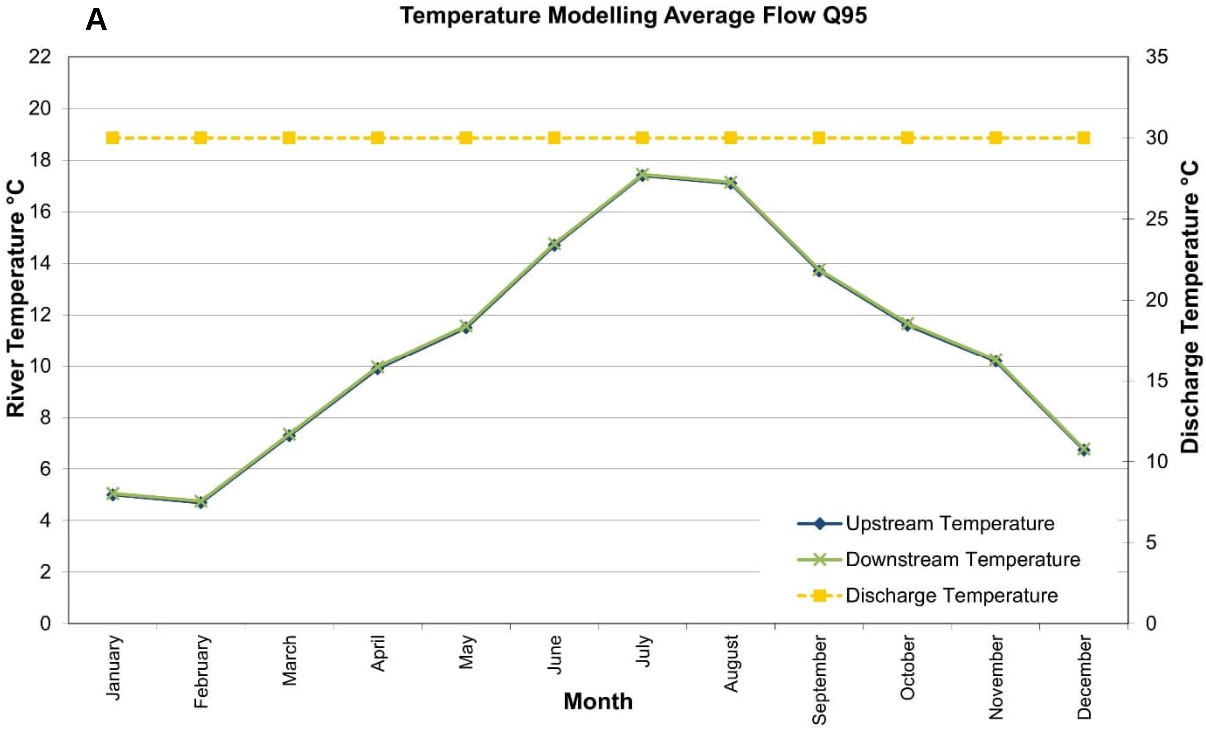
Table 4.2 Summary of the impact of the proposed discharge on temperature in the River Dee – Q95 river flow

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

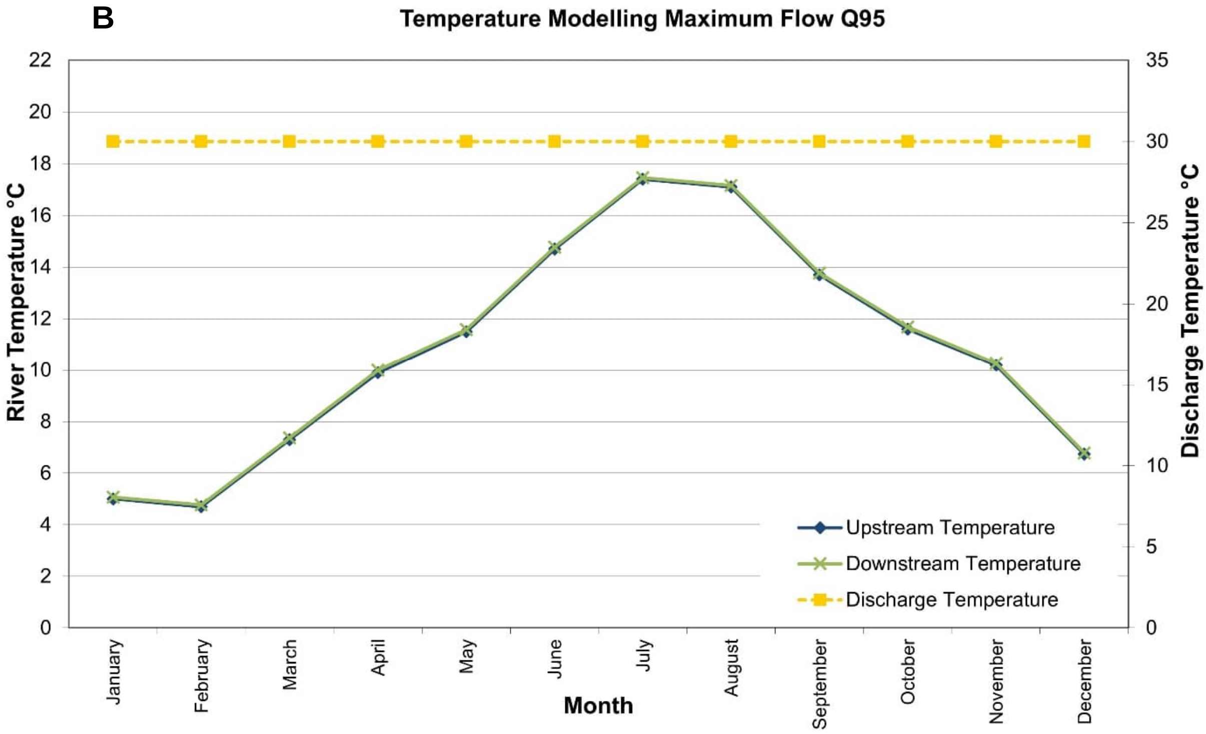
* Data from 2015 analysis

Figure 4.2 Comparison of monthly upstream and downstream river temperature profiles at low river flows (Q95)

A



B



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 increased discharge on the downstream river quality, specifically for determinands: BOD, ammonia, orthophosphate, and pH.

A mass balance spreadsheet tool was used to model the resultant river temperature downstream of the discharge.

The assessment was based on increased proposed discharge flows of 2,400 m^3/d (average) and 3,120 m^3/d (maximum), with quality based on the anticipated performance from a tertiary treatment plant.

The results showed that the predicted impact of the proposed discharge regime on downstream river quality was:

- A decrease (<4%) in the downstream in-river BOD, ammonia and orthophosphate concentrations was observed when compared to the in-river concentration predicted from the current permitted discharge (Table 3.5), for both the average and maximum proposed increase in discharge flow.

- At the maximum proposed increase in discharge flow, the comparison between upstream and downstream river quality showed that the:

    - orthophosphate downstream river concentration increased by 6.2% and 4.4% for the mean and 90 percentile respectively (Table 3.4).

    - ammonia downstream river concentration increased by 9.9% and 6.9% for the mean and 90 percentile respectively (Table 3.4).

    - chloride downstream river concentration increased by 12% and 11.8 % for the mean and 90 percentile chloride. This equates to a 7.4% and 7.3% increase in mean and 90 percentile respectively when compared the current maximum discharge (1,500 m^3/d).

- No change was predicted for pH.

- All predicted downstream river concentrations were lower than the relevant river standards, i.e. the river is predicted to be compliant with the EQS of High Status for BOD and ammonia and Good Status for orthophosphate.

- The monthly temperature modelling showed a very small increase (to the second decimal place) in river temperature for the current and proposed discharges, under both average and Q95 (low) flow conditions in the river; however, the spreadsheet tool assumes full and instantaneous mixing whereas in reality 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.

Hatton-Lewis TW, Jones TG. 2021. Compliance Assessment of Welsh River SACs against Phosphorus Targets. NRW Evidence Report No: 489, 96pp, Natural Resources Wales, Bangor

Appendix A Detailed results from RQP

Maelor Foods - RQP Analysis Outputs 2023.xlsx (dated 27.02.23) contains the RQP modelling inputs and results and has been provided electronically as an appendix to this report.