Appendix 12.3. WAC Assessment

AtkinsRéalis

WAC Assessment

Uisce Éireann

18 February 2026

5161805DG0434

CIP 5 - MORTARSTOWN WWTP

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1. Introduction

Uisce Éireann intend upgrading the existing Mortarstown WWTP from a current design capacity of 36,000 PE to a future forecasted 25 year design horizon loading of 58,500 PE. The Mortarstown WWTP services Carlow Town and environs and the plant is located 2.2km south of Carlow Town on the eastern bank of the River Barrow. The purpose of this report is to provide details of the water quality environment of the discharge and set out the calculations carried out to determine appropriate future Environmental Limit Values (ELVs) for the upgraded WWTP.

The upgrade project aims to increase the treatment capacity of the WWTP; replace equipment and electrical control equipment nearing the end of their working design life and address deficiencies related to stormwater storage volumes and shallow walled final settlement tanks.

The upgraded WWTP will discharge treated effluent to the River Barrow (WFD code IE SE 14 196) at grid reference 271,179E 174,892N. The existing Ø600mm outfall pipe will be replaced by a new Ø900mm outfall pipe discharging via a concrete headwall constructed to UÉ specifications. The impact of the future discharges on water quality in the River Barrow will be assessed using a Tiered Assessment approach as set out in the Uisce Éireann Interim Technical Guidance on Water Quality Impact Assessment in the Freshwater Environment (UÉ-AMT_GL-028).

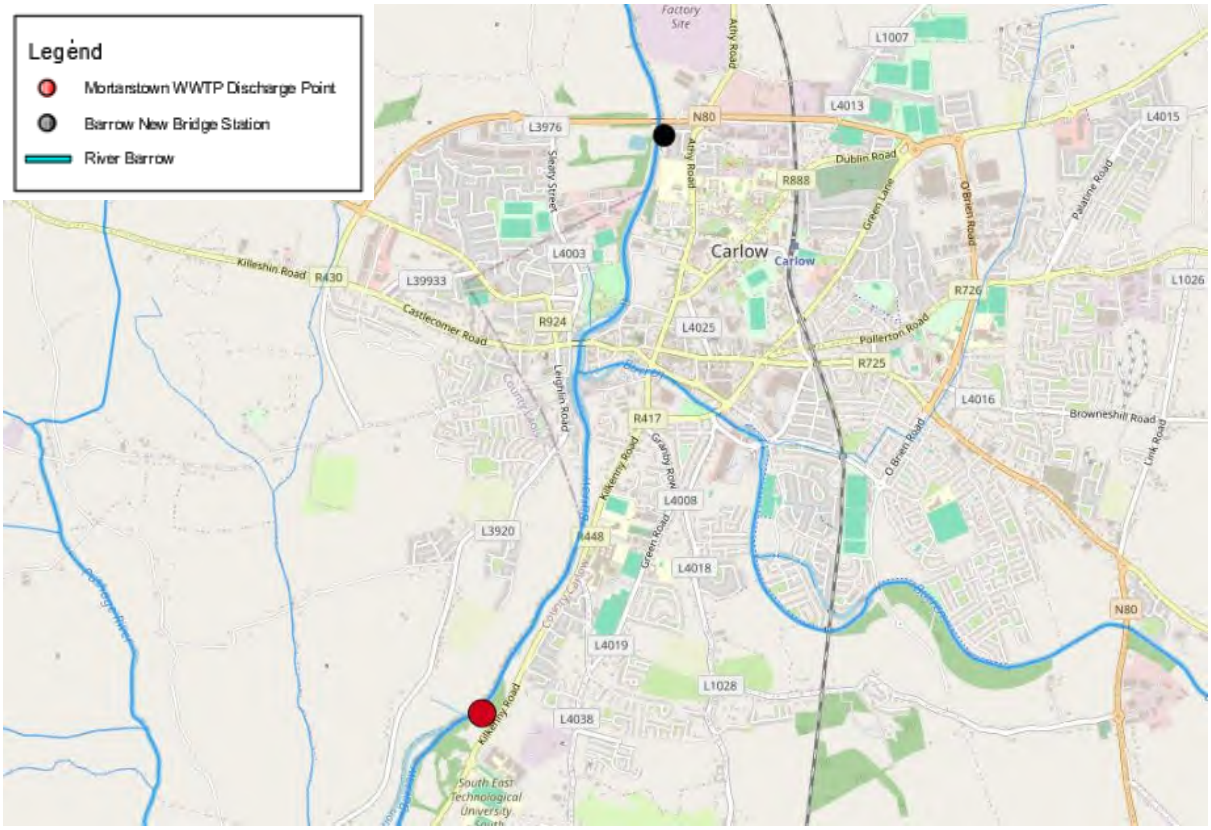

Figure 1-1 - Location of Mortarstown WwTP Discharge Outfall

1.1 Tiered Assessment Framework

An assessment of the impacts of the discharge from Mortarstown WWTP can be made using the Tiered Assessment Approach, as set out by the European Commission[1] and as adopted by Uisce Éireann's own Technical Guidance. The guidelines set out an approach to assessing the impact of discharges, using risk-based methods, where the level of complexity of the assessment is commensurate with the level of risk posed by a discharge.

The UÉ tiered approach for watercourses consists of five Tiers:

- Tier 0: check to see if the effluent is likely to contain a contaminant of concern. If so, check to see if the contaminant is present at levels above the Environmental Quality Standard (EQS), i.e. the maximum permitted concentration in the receiving waterbody.
- Tier 1: Check to see if discharging the contaminant(s) of concern at levels above the EQS are likely to have a significant impact on the receiving waterbody given existing ambient concentrations.
- Tier 2: An initial assessment of water quality impacts and required ELVs is made based on a simple mass balance approach (Tier 2a). If this is found to give unrealistic results, or if the resulting ELVs cannot be achieved in a cost-effective and proportionate manner, the water quality impact is further simulated using a Monte Carlo analysis (Tier 2b).
- Tier 3: If the Tier 2 assessment methods indicate that achievable ELVs cannot be applied to the discharge, or sensitive receptors are likely to be impacted upon, the mixing zone is further assessed based on achievable levels of wastewater treatment and using complex models to establish the extent of the mixing zone and duration and frequency of impacts.
- Tier 4: If the Tier 3 analysis suggests that the impacts will be significant, an investigative study is undertaken to examine the concentrations of the contaminant(s) reaching receptors, the characteristics of the receptors, their vulnerability and the ecotoxicity of the contaminants.

At each stage of the Tiered Assessment, the discharge assessment is either completed (if environmental impacts are appropriate and acceptable) or referred for additional assessment at the next stage. In the case of Mortarstown WWTP, the level of required analysis did not progress beyond a Tier 2 assessment.

The two methods of Tier 2 calculation are described below.

1.1.1 Simple Mass Balance Method

Simple mass balance calculations can be carried out for any given set of river quality, river flow, effluent quality and effluent flow conditions. For the purposes of assessing impacts of wastewater discharges against targets in legislation (see Section 2) two sets of calculations are typically required, the first to assess against environmental compliance with 95%ile EQS targets (carried out using low Q95 river flows) and a second calculation to assess environmental compliance against mean EQS targets (carried out using mean river flows). The calculation is shown in Equation 1.

$$C_{downstream} = \frac{Q_{eff}C_{eff} + Q_{river}C_{river}}{Q_{eff} + Q_{river}}$$

Equation 1-1 - Mass Balance Equation

Where: Q_{eff} is the average effluent flow rate (m^3/s) and Ceff is the effluent pollutant concentration (mg/l)

[1] Technical Guidelines for the Identification of Mixing Zones, pursuant to Art. 4(4) of the Directive 2008/105/EC, European Commission, Brussels, 22 December 2010, C(2010) 9369

Q_{river} is the flow in the watercourse upstream (m^3/s) and Criver is the average ambient river pollutant concentration upstream of the outfall (mg/l)

$C_{downstream}$ is the resultant downstream water quality for each pollutant in the watercourse (mg/l)

The simple mass balance approach assumes that 95%ile concentrations in the river occur downstream of a discharge at the same time as Q_{95} river flows due to lack of dilution capacity within the watercourse at times of low flow. This approach also assumes that mean concentrations in the river occur downstream of a discharge at the same time as mean river flows. Because of this method of schematising river quality conditions, simple mass-balance may be considered a conservative approach compared to other methods of modelling which are a capable of considering a much wider combination of flow and quality conditions in rivers and effluent.

1.1.2 Monte Carlo Analysis Method

If the ELVs determined on the basis of the simple mass balance (Tier 2a) approach are found to be unrealistic or give rise to ELVs that cannot be achieved in a cost-effective and proportionate manner, then the water quality impact can be simulated in greater detail using a Monte Carlo analysis (Tier 2b).

Whilst the simple mass-balance calculations are easy to apply, they do not consider the full range of river and effluent flow conditions or the range of potential quality conditions which may occur in a watercourse upstream or downstream of a discharge. The simple mass balance approach is also not able to easily take account of correlations between inputs, such as correlations between river and effluent flow rates or between effluent flow rate and effluent pollutant concentrations. These factors can be overcome using a Monte Carlo approach whereby complex statistical problems are represented using multiple different combinations of potential scenarios selected randomly from across the probability curves of both datasets. In this context, Monte Carlo analysis uses multiple combinations of watercourse and effluent flows and concentrations in order to assess the impact of the discharge over the full range of potential watercourse flow and quality conditions. This gives a more complete analysis of the impacts of a discharge on the watercourse quality and can also be adapted to account for correlations in datasets, however it does require more input data compared to a simple mass-balance approach.

Uisce Éireann have developed methods to facilitate both simple mass balance (UÉ-AMT-FM-007) and Monte Carlo analysis (UÉ-AMT-FM-008) when assessing the impacts of a WWTP discharge on receiving water quality. A simple mass balance approach has been applied to assess the impacts of the Mortarstown WWTP discharges on water quality in the River Barrow and calculate the ELVs required to deliver the appropriate level of protection to downstream water quality.

1.2 Report Structure

The report sets out the results of a Tiered Assessment of the Mortarstown WWTP discharge and calculation of ELVs based on simple mass balance Tier 2a assessment method. The Tier 2a calculation method relies on suitable analysis of the available environmental data and information on WWTP effluent flows and quality. The report is structured as follows:

- Section 2 provides a brief overview of legislative framework and list of substances for assessment in the tiered analysis.
- Section 3 sets out the hydrological context of the receiving waters and calculates river flow percentiles.
- Section 4 reviews the available water quality data for the receiving watercourses, checks for correlation between river flow and quality and establishes target downstream concentration values and status.
- Section 5 outlines the available effluent flow and quality data and checks for correlation between river flow and effluent flow rates and between effluent flow rate and quality.
- Section 6 provides the results of analysis at Tiers 0, 1 and 2 (simple mass balance approach).

- The report is summarised in Section 7.

2. Legislative Framework

2.1 Legislation

2.1.1 Urban Wastewater (Nutrient Sensitive Areas) Regulations

The Urban Wastewater (Nutrient Sensitive Areas) Regulations 2025[2] sets standards to be met in the collection and treatment of wastewater as well as the monitoring requirements for wastewater discharges from urban areas. The Environmental Protection Agency issues licences for WWTP discharges to environmental waters in accordance with the requirements of the UWWTD and the discharge licence for Mortarstown WWTP was most recently granted under this legislative instrument in August 2009 (ref. D0028-01), with technical amendments in October 2011, December 2016 and December 2021. The current ELVs applied to effluent from Mortarstown WWTP are set out in Table 2-1 and compared with effluent quality standards required for a wastewater treatment plant of its current capacity under the UWWTD.

Table 2-1 - Current Environmental Limit Values at Mortarstown WwTP

Parameter	UWWTD Maximum Permitted Value	Current Mortarstown WWTP ELV (WWDA Regs)
Chemical Oxygen Demand (COD) (mg/l)	125	125
Biological Oxygen Demand (BOD) (mg/l)	25	15
Suspended Solids (mg/l)	35	35
pH	--	6.0 to 9.0
Ammonia (mg/l)	--	2.0
Orthophosphate (mg/l)	--	0.80
Total Phosphorus (mg/l)	1.00	1.00

Under the UWWTD, secondary treatment is required for settlements with a PE of 2,000 to 10,000 and with discharges to freshwaters. Tertiary treatment is required for WWTP which serve more than 10,000 PE and which discharge to nutrient sensitive waters. The UWWTD allows for designation of environmental waters as "nutrient sensitive" and additional application of ELVs for total nitrogen and total phosphorus where this designation is applied. It is noted that the River Barrow, "*downstream of Portarlington sewage outfall, to Graiguenamanagh Bridge*" which incorporates the Mortarstown WWTP discharge point is designated as nutrient sensitive and a total phosphorus ELV has been applied by the current discharge licence in recognition of this.

2.1.2 Surface Waters Regulations

The Water Framework Directive (WFD, Directive 2000/60/EC) defines the ecological status of waterbodies as high, good, moderate, poor or bad. Under WFD, member states are required to prevent pollution of waterbodies and work to improve water quality to a minimum of good status, provided this can be done in a cost effective and proportionate

[2] Statutory Instruments SI No 403/2025 https://www.irishstatutebook.ie/eli/2025/si/403/made/en, accessed 12 February 2025

manner. The WFD was enacted into Irish Law through the European Communities Environmental Objectives (Surface Waters) Regulations 2009[3] (amended in 2015 and 2019 and referred to throughout this report as “the Surface Water Regulations”).

The Surface Water Regulations set standards which can be used to identify the current status of waterbodies and to determine the impacts of the discharge at Mortarstown WWTP on future water quality. The standards are set for ecological community assemblage and for physio-chemical parameters that affect it. Table 2-2 shows the standards for good and high ecological status in rivers. The discharges may directly impact on concentrations of ammonia, BOD, orthophosphate and pH and this will subsequently have impacts on river ecosystems and dissolved oxygen concentrations. This report will consider only direct impacts on river chemistry and will calculate the appropriate ELVs required to ensure protection of river ecosystems and avoid impacts on dissolved oxygen.

[3] Statutory Instruments SI No 77/2019 http://www.irishstatutebook.ie/eli/2019/si/77/made/en/print, accessed 26 September 2024

Table 2-2 - Water Quality Standards for River Waters under the Surface Water Regulations

Parameter	Classification System	High-Good boundary	Good-Moderate boundary
Macro Invertebrates	Quality Rating System (Q Value)	0.85	0.75
Fish	Fish Classification Scheme 2 Ireland (FCS2)	0.845	0.540
Phytobenthos	Revised form of Trophic Diatom Index (TDI)	0.93	0.78
Macrophytes	Free Macrophyte Index	0.90	0.68
Ammonia (mg/l)	Mean	0.04	0.065
	95%ile	0.09	0.14
BOD (mg/l)	Mean	1.3	1.5
	95%ile	2.2	2.6
Molybdate Reactive Phosphorus (orthophosphate, mg/l)	Mean	0.025	0.035
	95%ile	0.045	0.075
pH	Mean	Hard Water ($CaCO_3$ >100mg/l) = 6-9 Soft Water ($CaCO_3$ <100mg/l) = 4.5-9	
Dissolved Oxygen (%)	95%ile value	80-120%	

2.1.3 Wastewater Discharge (Authorisation) Regulations

The Environmental Protection Agency issues licences for WWTP discharges under the Wastewater Discharge (Authorisation) Regulations (2007)[4] (amended in 2010 and 2024), referred to in Table 1 as the WWDA Regulations. These regulations take account of the above directives to ensure that the discharge of wastewater does not have adverse impacts on the environment. This is achieved by taking a "combined approach," whereby "*the emission limits for the discharge are established on the basis of the stricter of either or both, the limits and controls required under the Urban Waste Water Regulations, and the limits determined under statute or Directive for the purpose of achieving the environmental objectives established for surface waters.*"

2.1.4 Other Regulations

Additional protection for water quality in rivers can be applied in Ireland under the following legislative instruments:

[4] http://www.irishstatutebook.ie/eli/2007/si/684/made/en/print, accessed 19 June 2020

- The EU Bathing Waters Directive (2006/7/EC, February 2006), transposed into Irish Law as the Bathing Water Quality Regulations[5] in 2008 with minor amendments in 2011 and 2016.
- The Shellfish Waters Directive ("Directive 2006/113/EC on the Quality Required of Shellfish Waters") which sets out standards which must be achieved when harvesting shellfish for human consumption and is now incorporated within the Water Framework Directive.
- The 1988 Salmonid Regulations[6] which have been partly superseded by the Water Framework Directive.
- Habitats Directive (Directive 92/43/EEC): Treated effluent from the Mortarstown WWTP discharges and will continue to discharge to the River Barrow and River Nore Special Area of Conservation (SAC). In order to inform and assist the competent authority in making its Appropriate Assessment (AA) of the proposed Mortarstown WWTP upgrade development under Article 6(3) of the Habitats Directive, a Natura Impact Statement (NIS) will be prepared and submitted to the competent authority. The NIS will assess the implications of the WWTP upgrade project for the integrity of the SAC. As part of this, the outputs of this WAC Report will provide a basis for the assessment of the effects of the future effluent discharge on the aquatic qualifying interests of the SAC, in view of their conservation objectives.

The Barrow River is not designated as a bathing water, shellfish water or for the protection of salmon, therefore the Habitats Directive, of the above related legislative instruments apply when assessing the impacts of the Mortarstown WWTP discharge.

2.2 WFD Waterbodies

Mortarstown WWTP discharges to the Barrow River which is designated under the Surface Waters Directive as river waterbody Barrow_160 (IE_SE_14B012460) and the existing discharge location will be utilised by the upgraded WWTP. The Barrow Catchment includes the area drained by the River Barrow upstream of the River Nore confluence and all streams entering tidal water between the Barrow railway bridge at Great Island and Ringwood, Co. Kilkenny, draining a total area of 3,025km². The largest urban centre in the catchment is Carlow. The other main urban centres in this catchment are New Ross, Graiguenamanagh, Athy, Portlaoise, Mountmellick, Portarlington, Monasterevin and Kildare. The Barrow main channel rises in the Slieve Bloom mountains and flows through agricultural areas, the towns of Portarlington, Athy, and Carlow.

The New Bridge Monitoring Station (RS14B012200 upstream of the WWTP Discharge Point) identifies the waterbody as having a Moderate Q Value Status with a Q Value Score of 3-4 in 2023. The Q Value score at this Monitoring Station (RS14B012200) in 2018, 2020 and 2023 has not changed. An examination of the Monitoring Station Data indicates that an upstream Good Q Value Status is monitored at a Monitoring Station upstream of Athy (RS14B011300). Monitoring Stations (RS14B012455, RS14B012600, RS14B012680) downstream of the Mortarstown WWTP Discharge Point) identifies the waterbody as having a Moderate Q Value Status with a Q Value Score of 3-4 in 2018, 2020 and 2023.

The available water chemistry data for the River Barrow upstream and downstream of the Mortarstown WWTP Discharge Point is reviewed in Section 4.

[5] Statutory Instrument 79/2008, https://www.irishstatutebook.ie/eli/2008/si/79/made/en/print, accessed 12 March 2024

[6] http://www.irishstatutebook.ie/eli/1988/si/293/made/en/print, accessed 12 March 2021

2.3 Sensitive Receptors

Treated effluent from the Mortarstown WWTP discharges and will continue to discharge to the River Barrow and River Nore Special Area of Conservation (SAC). As noted in Section 2.1.4, the River Barrow is not designated for protection of bathing waters, shellfish or salmon and improvements to wastewater treatment are not required at this location for the protection of freshwater pearl mussel. There are no Uisce Éireann Drinking Water Abstraction Points identified downstream of the primary discharge. The watercourse is, however, designated as nutrient sensitive. The additional protection required under the UWWTD for nutrient sensitive waters is reflected in the application of the total phosphorus ELV and this is applied irrespective of receiving water quality. The substances of concern for a Teir 0 analysis in Section 6 are therefore limited to ammonia, BOD, orthophosphate and pH based on EQS for rivers as set out in the Water Framework Directive.

2.4 Assessment Methodology

Uisce Éireann have developed a methodology to ensure a consistent approach is taken to water quality impact analysis and the setting of ELVs for WWTP effluent (Interim Technical Guidance for Water Impact Assessments (Freshwater) Document No. AMT-GL-028). This approach seeks to determine an appropriate downstream target status and percentage of available wastewater assimilative capacity which can be taken by a single wastewater discharge. The available assimilative capacity is defined as the difference between the upstream river nutrient concentration and the target EQS.

Figure 2-1 provides a flow chart for identifying the target status for a watercourse as either “Good” or “High” status, and if a notionally clean approach should be applied. The flow chart is applied for both mean and 95%ile water quality, with the final target applied for each nutrient based on the worst-case upstream water quality evaluation outcome.

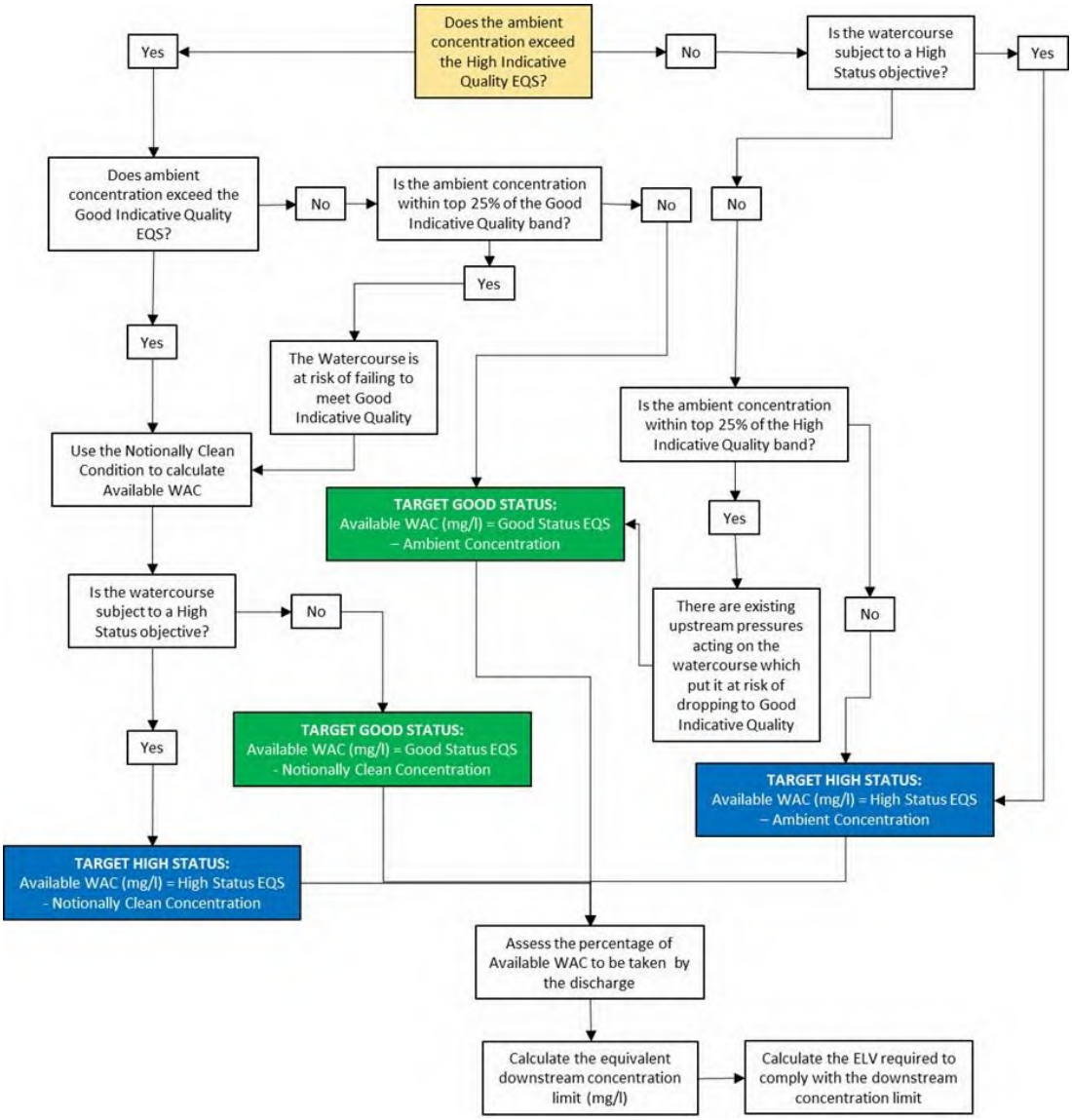

Figure 2-1 - Target Status Flow Chart

The calculation of available assimilative capacity in watercourses is predicated on the assumption that the ambient water quality is less than the EQS for each pollutant. This may not be the case in all circumstances as often a waterbody may have other upstream pressures impacting on water quality. In such circumstances a “Notionally Clean” approach is required to determine appropriate ELVs which are proportionate to the impacts of a wastewater discharge on the environment. The impact of the upstream pressures is “removed” to allow for calculation of ELVs which would deliver compliance with the target status under the Surface Water Regulations if the upstream pressures on water quality were addressed. This is simulated by applying water quality statistics at the upstream location which are equal to 20% of the high status EQS value. These approaches are required to allow for sustainable future operation of wastewater infrastructure in line with the “polluter-pays” principle in the WFD.

The outcome of this process for Mortarstown WWTP, based on the upstream river quality data discussed in Section 4 below, is that A “Notionally Clean” approach was adopted in the calculation of the ammonia and BOD ELV as the ambient river data exceeds the Good Indicative Quality EQS for BOD and ammonia.

For a given WWTP, ELVs are set such that effluent discharges utilise an appropriate percentage of the available WAC based on the sensitivity of the receiving environment. Table 2-3 provides an environmental sensitivity scoring system,

which determines this sensitivity based on the characteristics of the receiving environment. The environmental sensitivity score calculated for the Barrow River at Mortarstown WWTP Discharge Point is 15.

Table 2-3 - Environmental Sensitivity Scoring

Factor	Assessment	Score	River Barrow at Mortarstown WWTP Discharge Point
Current watercourse status	Watercourse not at significant risk of WFD classification change	0	
	Watercourse “at risk” of WFD classification change / currently failing to meet Good	5	5
Discharge Location Score			
Downstream Dilution	Q_{95} Flow increases by <20% at next confluence (within WFD Waterbody)	0	0
	Q_{95} flow increases by 20-50% at next confluence (within WFD Waterbody)	-2	
	Q_{95} flow increases by >50% at next confluence (within WFD Waterbody)	-2	
	Q_{95} flow increases by >80% at next confluence (within WFD Waterbody)	-4	
Environmental Receptors Score			
Environmental Receptors	Discharge to SPA	5	
	Discharge to Special Area of Conservation	5	5
	Discharge to Bathing Water	5	
	Discharge to Drinking Water	3	
	Discharge to Salmonid River	4	
	Discharge to Shellfish Water	2	
	Discharge to Nutrient Sensitive Water	5	5
	Discharge within 1km of SPA	2.5	
	Discharge within 1km of SAC	3	

Factor	Assessment	Score	River Barrow at Mortarstown WWTP Discharge Point
	Discharge to High Status Objective Waterbody under WFD or the Habitats Directive	10	
	Discharge within 1km of Bathing Water	2.5	
	Discharge within 1km of Drinking Water	1.5	
	Discharge within 1km of Salmonid River	3	
	Discharge within 1km of Nutrient Sensitive Water	3	
	Discharge within 1km of Shellfish Water	1	
		TOTAL	**15**

Table 2-4 provides the upper limits of the available WAC to be used by a WWTP discharge depending on the environmental sensitivity score and the upstream water quality. Based on the scores calculated above, Mortarstown WWTP should use 30% (at most) of the available WAC. Note the available WAC for BOD and ammonia to be based on the notionally clean condition.

Table 2-4 - Determination of Available WAC Take-Up

Risk Score	Amount of Available WAC to be Taken (Using Ambient Data)	Amount of WAC to be Taken (Using Notionally Clean)
up to 4	Up to 75%	Up to 50%
4 to 9	Up to 50%	Up to 40%
10 to 19	Up to 30%	Up to 30%
19 to 30	Up to 25%	Up to 20%
>30	Up to 10%	Up to 10%

3. Hydrological Analysis

A detailed hydrological analysis has been undertaken in accordance with Uisce Eireann's Technical Guidance for Hydrological Estimation (UE-AMT-GL-022) in order to determine the prevailing river flow characteristics at the Mortarstown WWTP discharge location.

3.1 River Barrow Catchment and Flow Gauges

The Barrow River catchment at Mortarstown WWTP discharge point occupies an area of 2,255.7km^2 (Figure 3-1). The Barrow New Bridge Station (Stn. No. 14022) is located 3 km upstream of the Mortarstown WWTP discharge point, where the catchment area is 2,069.5km^2. The difference in catchment area between the gauge station and the discharge point is 8.2% (Figure 3-2). As the difference in catchment areas at the gauge station and the discharge site is less than 10%, therefore the flow duration curve at the gauge station can be applied to the WWTP discharge site with simple scaling to account for the difference in catchment area.

The gauged river flow record at the Barrow New Bridge Station is used to calculate river flow statistics at Mortarstown WWTP discharge point. The Q_{95} river flow data for the downstream Pushoge River was identified at 0.039m^3/s (ref EPA Maps) indicating that the increase in Q_{95} river flow occurring downstream of the River Barrow/Pushoge River confluence is less than 20% with a 0 score therefore being used as an input to the Environmental Sensitivity Score in Section 2.4.

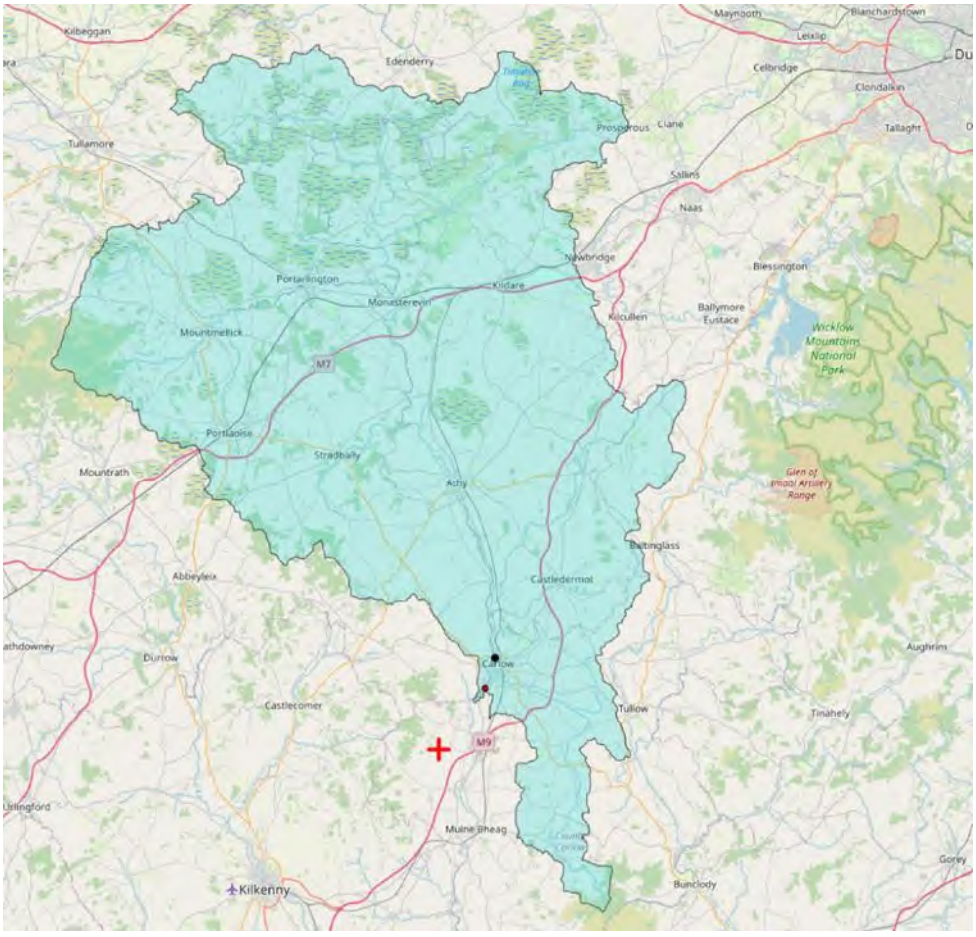

Figure 3-1 - Mortarstown WWTP Discharge Point Contributing Catchment Area

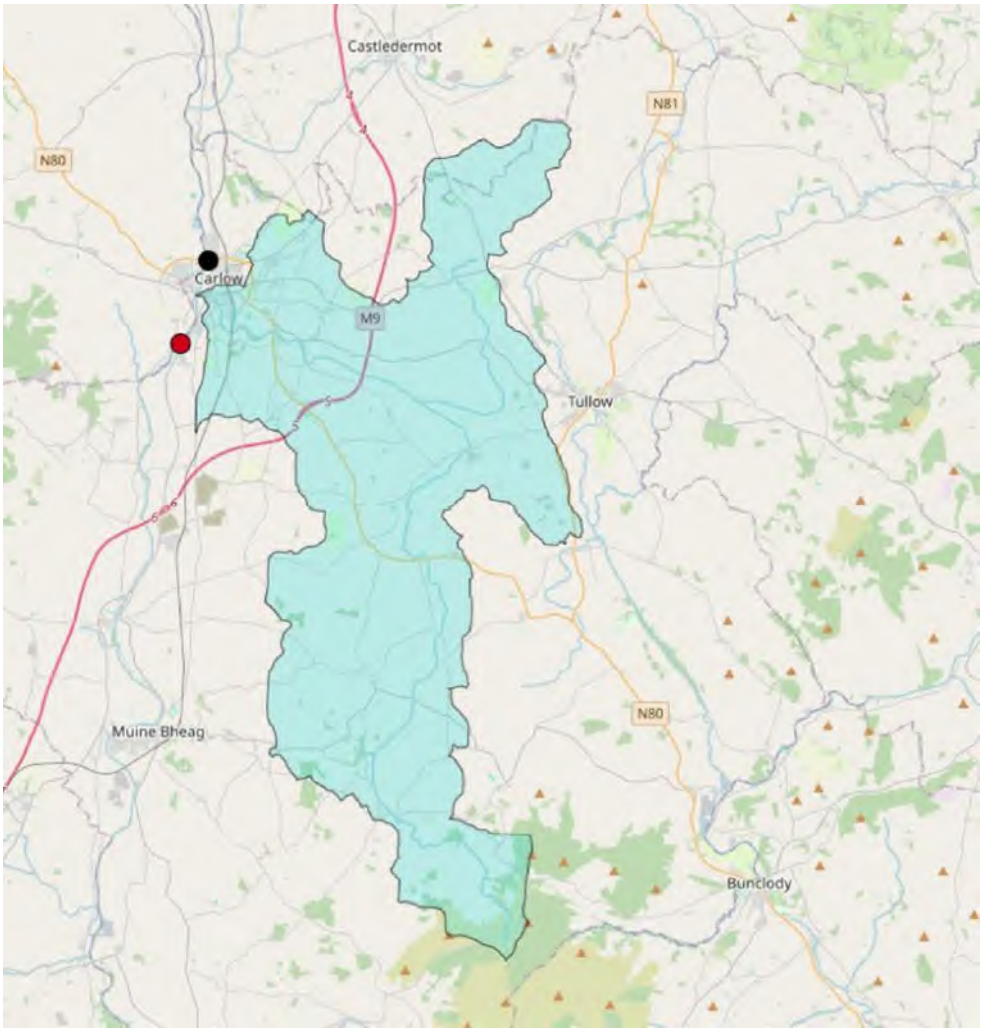

Figure 3-2 - Catchment Area not contributing to Barrow New Bridge Station

3.2 Gauged Flow Data Evaluation

Details of the gauged flow data at the Barrow New Bridge Station are provided in Table 3-1 and the annual flow data and calculated flow percentiles at the gauge station is set out in Appendix A.

Table 3-1 - Gauging Station Details

Station Number	14022
Station Name	Barrow New Bridge
Waterbody	River Barrow
Site Owner	Office of Public Works
Grid Reference	272025, 177741
River Basin District	South Eastern

Catchment Area (km^2)	2,065.5
Data Start Date	21/09/2007
Data End Date	05/11/2024
Daily Data Percent Complete	91.2

The Barrow New Bridge daily flow data timeseries is shown in Figure 3-3 (OPW, 2024) and the gauge data have been reviewed for quality, non-stationarity and the impact of missing data.

The review shows that the majority of the river daily flow data timeseries as being complete with no gaps sufficient to skew the flow duration curve. The review shows that the majority of the river daily flow data timeseries is classified by the OPW as being of an acceptable or fair quality (OPW quality codes 31,36). An ADF test for stationarity indicates that flow data timeseries as having a non-stationarity characteristic in the form of reducing low annual flows, however this non-stationarity is not sufficiently apparent to justify exclusion of older data when calculating whole-record river flow statistics. Anthropogenic (or human based) influences on gauged river flow data at Barrow New Station are not considered to be significant. The upstream Srowland water treatment plant at Athy for example operates at 20 ML/d or 0.23m^3/s which is not considered to be sufficiently significant relative to the River Barrow flow to skew the Barrow New Station flow duration curve.

One the basis of these checks, the daily mean flow data from the entire gauge record from the Barrow New Station can be used to produce a flow duration curve and calculate key flow percentiles for the River Barrow at the gauge. Flows at the gauge can be scaled to represent flows in the River at Mortarstown WWTP to account for the increase in catchment area between the gauge and the WWTP discharge point.

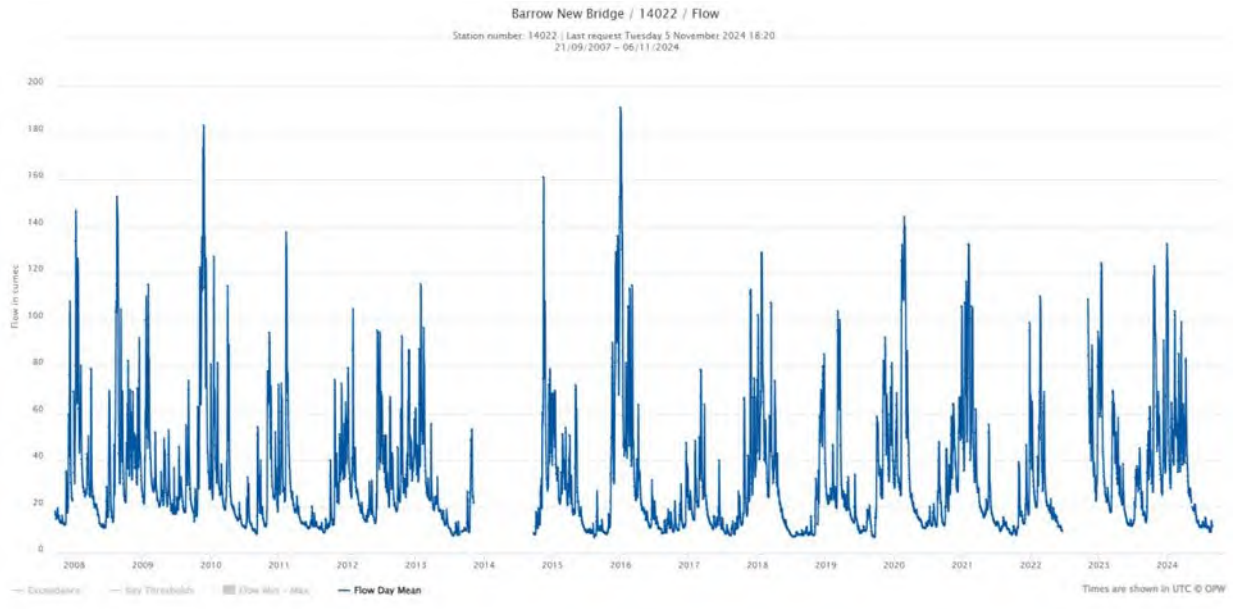

Figure 3-3 - OPW River Flow Timeseries for River Barrow at Barrow New Bridge (Daily Mean Flows from 2008 to 2024)

3.3 Gauged Flow Statistics

Figure 3-4 (OPW, 2024) shows the flow duration curve for the River Barrow at the Barrow New Bridge Station for period 2007 to 2024. River flow statistics have been calculated for the River Barrow at Mortarstown WWTP discharge

point by increasing the gauged flows at Barrow New Bridge Station by 8.2% to account for the increase in catchment area between this gauge and the WWTP. Table 6 gives the scaled river flow statistics for the River Barrow at Mortarstown WWTP discharge point.

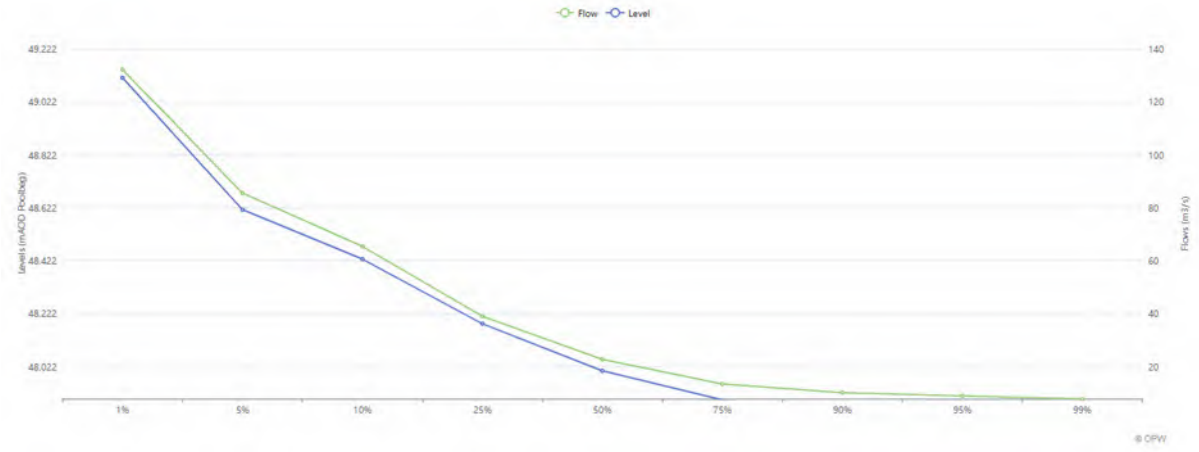

Figure 3-4 - OPW Daily Mean Flow Duration Curves for the River Barrow at Barrow New Bridge Station

Table 3-2 - Flow Duration Curve Statistics for the River Barrow at Guage Station & Mortarstown WWTP Discharge Point

Flow Exceedance Probability (%)	New Bridge Barrow OPW Gauge Station Flow (m^3/s)	Mortarstown WWTP Discharge Point Flow (m^3/s)
1	132.118	142.952
5	85.439	92.445
10	65.289	70.643
25	38.877	42.065
50	22.589	24.441
75	13.312	14.404
90	10.03	10.852
95	8.792	9.513
99	7.69	8.321

4. River Water Quality Analysis

4.1 Monitoring Locations

River water quality is monitored on the River Barrow at locations upstream and downstream of Mortarstown WWTP discharge point. The upstream monitoring point is RS14B012310 (u/s Mortarstown WWTP), located at Graiguecullen

Bridge, ≈1.8km upstream of the primary outfall. The downstream monitoring point is RS14B012460 (d/s Mortarstown WWTP) located at Dolmen Mews, ≈1.0km downstream of the primary outfall. Details of the sampling monitoring point locations are shown in Table 7.

Table 4-1 - Water Quality Sampling Point Details

	Upstream Sampling Point			Downstream Sampling Point		
Station ID	RS14B012310			RS14B012460		
Station Name	u/s Mortarstown WWTP			d/s Mortarstown WWTP		
Irish Grid Reference	271637, 176643			270576, 174121		
Substance	**Ammonia**	**BOD**	**PO4**	**Ammonia**	**BOD**	**PO4**
Number of Samples	43	43	43	42	43	43
Date of First Sample	08/01/2020					
Date of Last Sample	14/02/2024					

4.2 River Quality Timeseries

The timeseries of ammonia sampling data at the two sampling points is shown in Figure 4-1. In general, the data shows a consistent ambient concentration of ammonia, with the downstream concentrations being usually slightly higher. Two high concentration values were observed in 2023. There are no obvious trends in the river quality data which would make data from a specific period of time unrepresentative of current conditions, so the entire period of record is suitable for the calculation of water quality statistics in the River Barrow.

Comparing the ammonia concentration at the upstream monitoring point RS14B012310 with the mean river flow recorded at the New Barrow Bridge gauge shows a weak correlation between upstream river flow and the u/s ambient Ammonia quality (R^2 = 0.117).

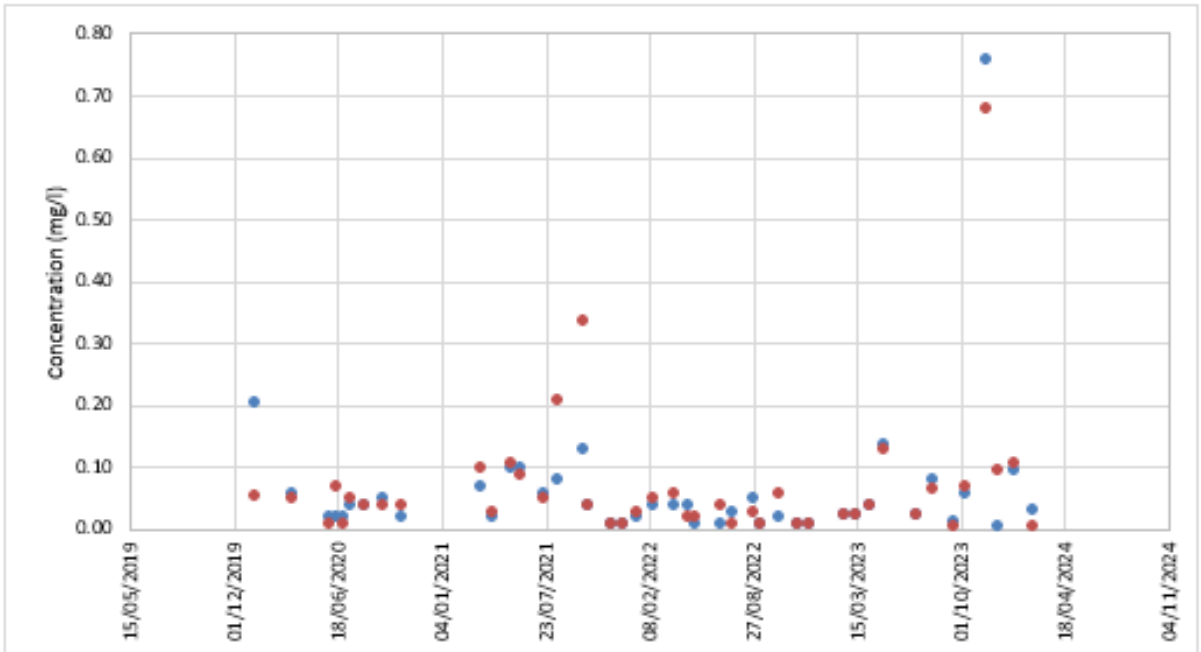

Figure 4-1 - Ammonia Monitoring Data for the River Barrow at Mortarstown WWTP

The timeseries of BOD sampling data at the two monitoring points is shown in Figure 4-2. There is generally limited difference in BOD concentration between the two sampling points, with upstream concentrations either slightly higher or slightly lower than at the downstream location. It is noted that the data shows elevated levels of BOD in 2022 for both upstream and downstream locations, which make the 2022 period less representative of current conditions. In line with typical water quality statistical analyses, values at or below LOD levels have been replaced with proxy values of 50% of the LOD when calculating statistical metrics. The limit of detection is higher than the mean EQS for BOD in rivers so mean BOD concentrations may be overestimated at Mortarstown relative to the EQS. This is not expected to impact significantly on the 95%ile river concentration.

Comparing the BOD concentration at the upstream monitoring point RS14B012310 with the mean river flow recorded at the New Barrow Bridge gauge shows no correlation between upstream river flow and the u/s ambient BOD quality (R^2 = 0.021).

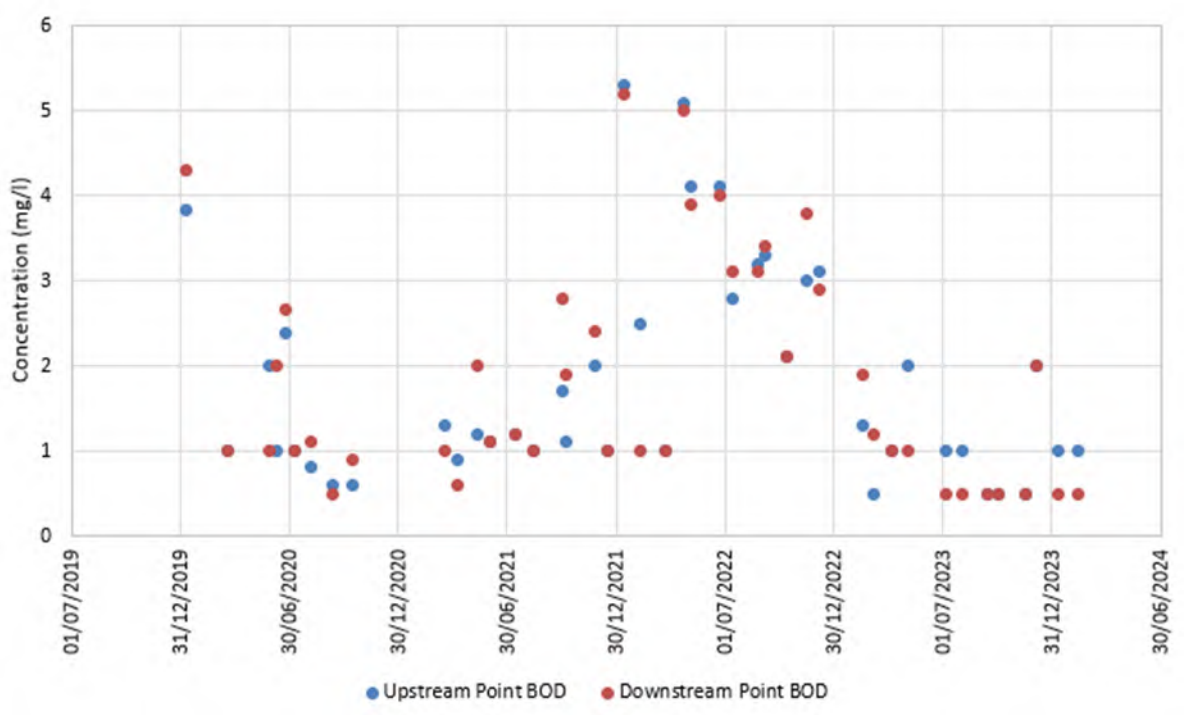

Figure 4-2 - BOD Monitoring Data for the River Barrow at Mortarstown WWTP

The timeseries of orthophosphate sampling data at the two sampling points is shown in Figure 4-3. In general, the data shows a consistent ambient concentration of orthophosphate with little difference between upstream or downstream concentrations. Two higher downstream concentration values were observed in period 2023. There are no obvious trends in the river quality data which would make data from a specific period of time unrepresentative of

current conditions, so the entire period of record is suitable for the calculation of water quality statistics in the River Barrow. Comparing the river orthophosphate concentration at the upstream monitoring point RS14B012310 with the mean river flow recorded at the New Barrow Bridge gauge shows a weak correlation between upstream river flow and the u/s ambient river orthophosphate quality (R^2 = 0.122).

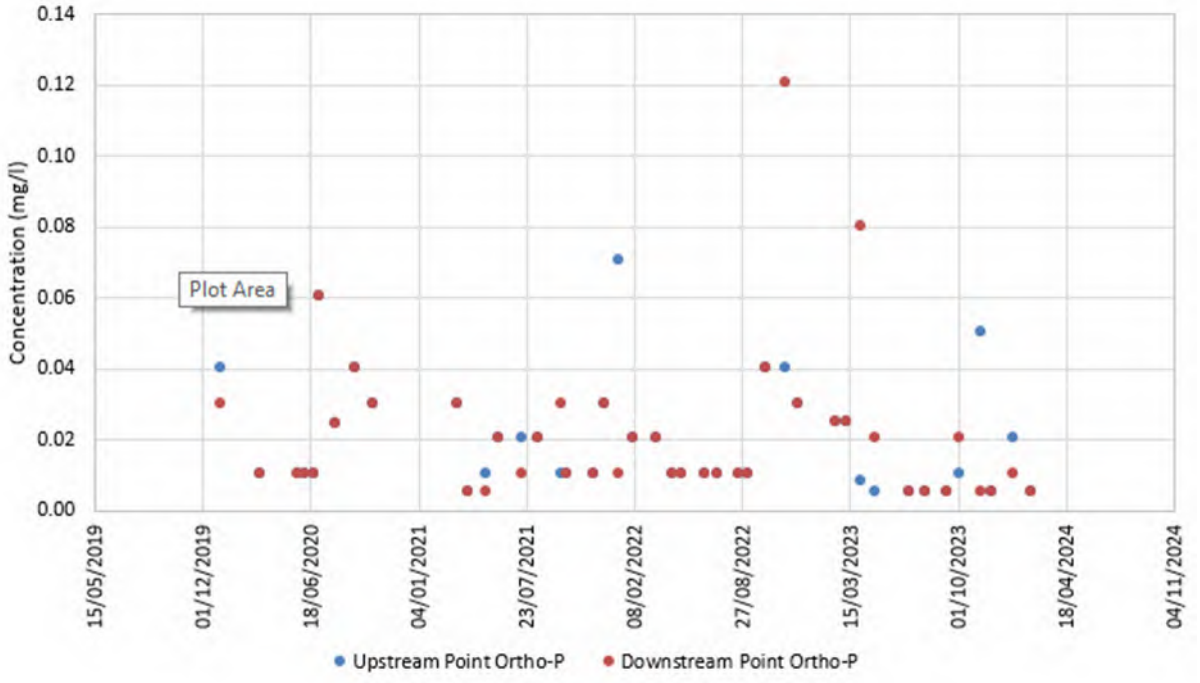

Figure 4-3 - Orthophosphate Monitoring Data for the River Barrow at Mortarstown WWTP

4.3 Ambient Water Quality Data

Table 4-2 sets out the overall water quality statistics for the River Barrow upstream and downstream of Mortarstown WWTP discharge point. Statistics are provided for mean and 95%ile quality for comparison with EQS under the Surface Water Regulations. Values which comply with requirements for high indicative quality are highlighted in blue, values which comply with requirements for good indicative quality are highlighted in green and values which exceed the good status EQS are highlighted in orange.

The difference in water quality statistic values between the upstream and downstream monitoring points at Mortarstown WWTP is generally small.

The EQS for good status for ammonia is **w**ithin the top 25% of the Good indicative quality band, see Figure 2-1 at the upstream location and is exceeded for both the mean and 95%ile condition at the downstream location.

The EQS for good status for BOD is exceeded for both the mean and 95%ile condition at both the upstream and downstream locations. An analysis of the ambient BOD concentrations excluding the elevated trend in 2022 identified that the BOD EQS for good status for BOD is exceeded for both the mean and 95%ile condition.

The mean EQS for high quality for orthophosphate is maintained at both locations and the 95%ile EQS for good indicative quality for orthophosphate is also maintained at both locations.

Table 4-2 - Water Quality Sampling Point Statistics

	RS14B012310 (Upstream)		RS14B012460 (Downstream)	
Substance	Mean	95%ile	Mean	95%ile
Ammonia (mg/l)	0.063	0.139	0.069	0.202
BOD (mg/l)	1.805	4.100	1.827	4.279
Orthophosphate (mg/l)	0.020	0.049	0.021	0.058

Since the mean and/or the 95%ile EQS concentration for good status is within the top 25% of the good indicative quality band, see Figure 2-1. and is exceeded at the downstream location for ammonia, ELVs cannot be set for effluent from the upgraded Mortarstown WWTP which would secure compliance with good status at the downstream point. This is due to upstream catchment pressures on water quality. As a result, the proposed ELV for ammonia is calculated with reference to the notionally clean condition as described in Section 2.4.

Since the mean and/or the 95%ile EQS concentration for good status is exceeded at the upstream location for BOD, ELVs cannot be set for effluent from the upgraded Mortarstown WWTP which would secure compliance with good status at the downstream point. This is due to upstream catchment pressures on water quality. As a result, the proposed ELV for BOD is calculated with reference to the notionally clean condition as described in Section 2.4.

5. Mortarstown WWTP Effluent Flow and Quality Data

5.1 Effluent Flow Data

Figure 5-1 shows the daily flow rate data for Mortarstown WWTP from January 2020 to April 2023. The observed mean effluent flow is 12,700m^3/d (0.147m^3/s).

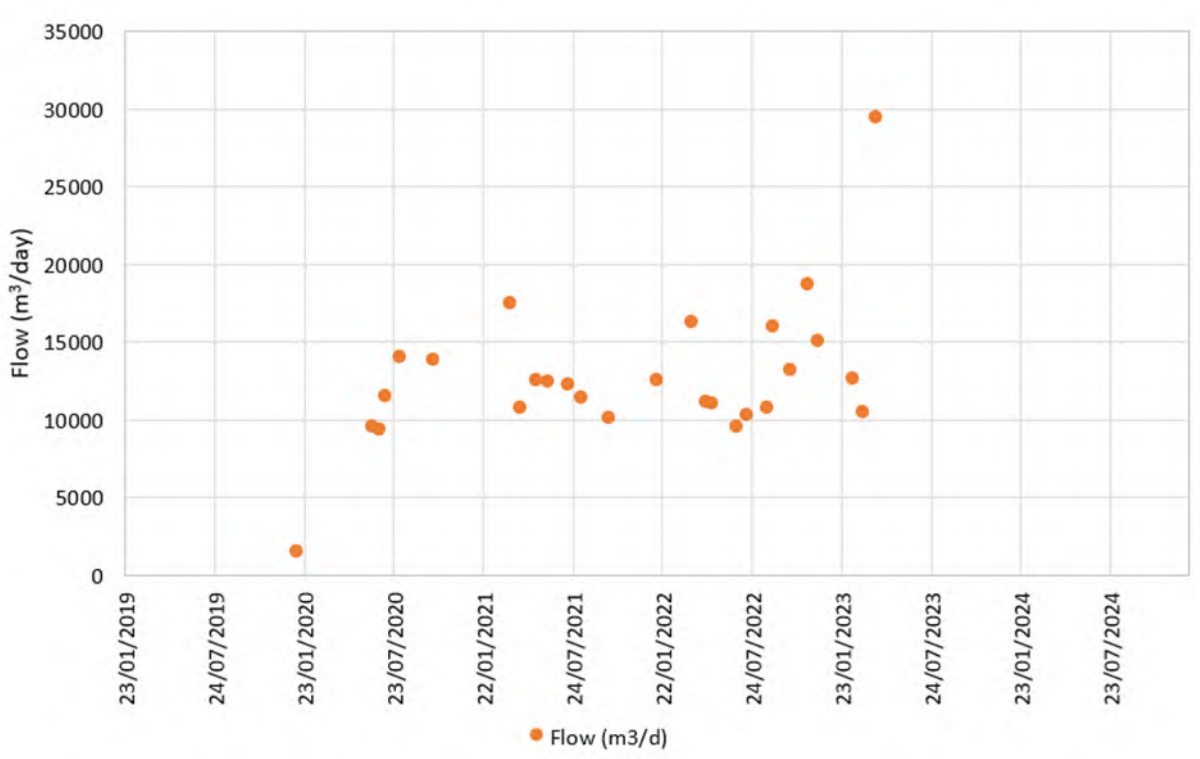

Figure 5-1 - Mortarstown WWTP Effluent Flow Timeseries

Flows at the New Bridge Barrow OPW gauge station were compared with the WWTP Effluent flow data and a weak positive correlation between the two data states was identified (R^2 = 0.354). The correlation between river and effluent flow is likely due to rainwater and groundwater ingress into the Carlow sewerage system during times of wet weather, with the weakness in the correlation may be due to the existing upstream storm overflows at the Kilkenny Road Pump Station and the different rainfall response times of the Barrow River Catchment and the Carlow Town sewer catchment network. It is proposed that this weak correlation is not considered in the water quality impact assessment because the upgrade involves the installation of new stormwater storage tanks at the WWTP, which will generally decouple the effluent flow rates and the river flow rates.

The upgraded Mortarstown WWTP has been designed to allow for growth in the agglomeration, with a commensurate increase in effluent flow rates. The design horizon includes a projected increase in population served by the WWTP from the current population equivalent of 39,270 to a population of 58,500 over the next 25 years. Table 9 presents the current dry weather (Q_{80}) effluent flow and anticipated future dry weather (Q_{80}) effluent flow. The mean flow anticipated under this scenario are also given for comparison; these flows were calculated by applying the PE flow scaling factor to the observed effluent flow dataset. The WWTP Design Flowrates have been calculated on the basis 1.25 x DWF with a unit flow of 225L/PE/day.

Table 5-1 - Current and Future Design Effluent Flow Rates

Design Horizon	Current		25-year	
PE Served	39,270		58,500	
Flow Increase Factor	1.00		1.48	
Effluent Flow Rates	m^3/d	m^3/s	m^3/d	m^3/s
Current Observed Dry Weather Flow (Q80)	10,368	0.120		
Predicted Future Dry Weather Flow (Q80)			15,344	0.177
Current Observed Mean Flow	12,700	0.147		
Future Design Flow (1.25 x DWF)			16,416	0.190

5.2 Effluent Quality

Figure 5-2, Figure 5-3, and Figure 5-4, show the observed effluent quality data in terms of ammonia, BOD and orthophosphate concentration. As noted in Section 4.2, in line with typical water quality statistical analyses, values at or below LOD levels have been replaced with proxy values of 50% of the LOD when calculating statistical metrics. The effluent data shows compliance with the current ammonia ELV with over 85% of the samples having an Ammonia concentration less than 0.2mg/l. The effluent data shows compliance with the current BOD ELV with over 97% of the samples having a BOD concentration less than or equal to 6 mg/l. The effluent data shows compliance with the current orthophosphate ELV with over 93% of the samples having an orthophosphate concentration less than or equal to 0.5 mg/l.

Table 10 compares the average effluent concentration of substances limited by ELVs in Section **Error! Reference source not found.** against observed 2020-2024 averages. Mortarstown WWTP complied with the relevant ELVs during this time period. There are weak correlations between effluent flow rate and effluent concentrations of ammonia (R^2=0.168) and orthophosphate concentrations (R^2=0.160) and no correlation for BOD (R^2 = 0.023) showing that the current WWTP functions well under the observed range of effluent flow conditions.

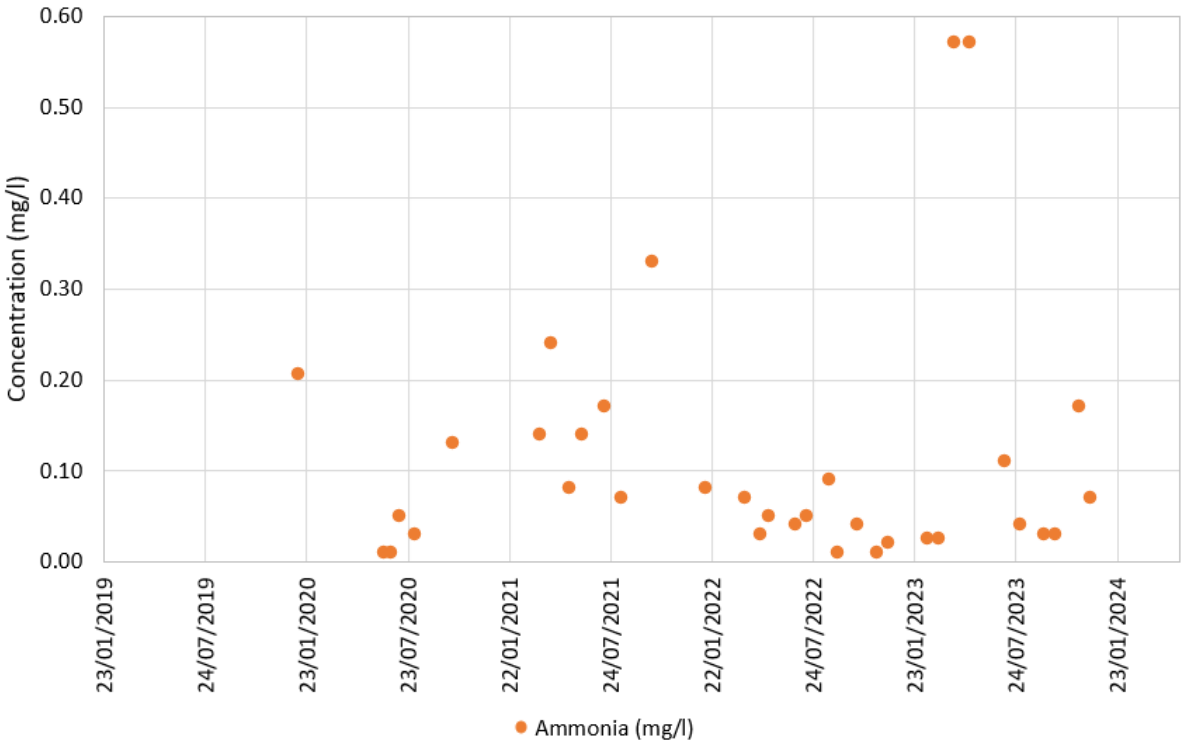

Figure 5-2 - Mortarstown WWTP Effluent Ammonia Concentrations

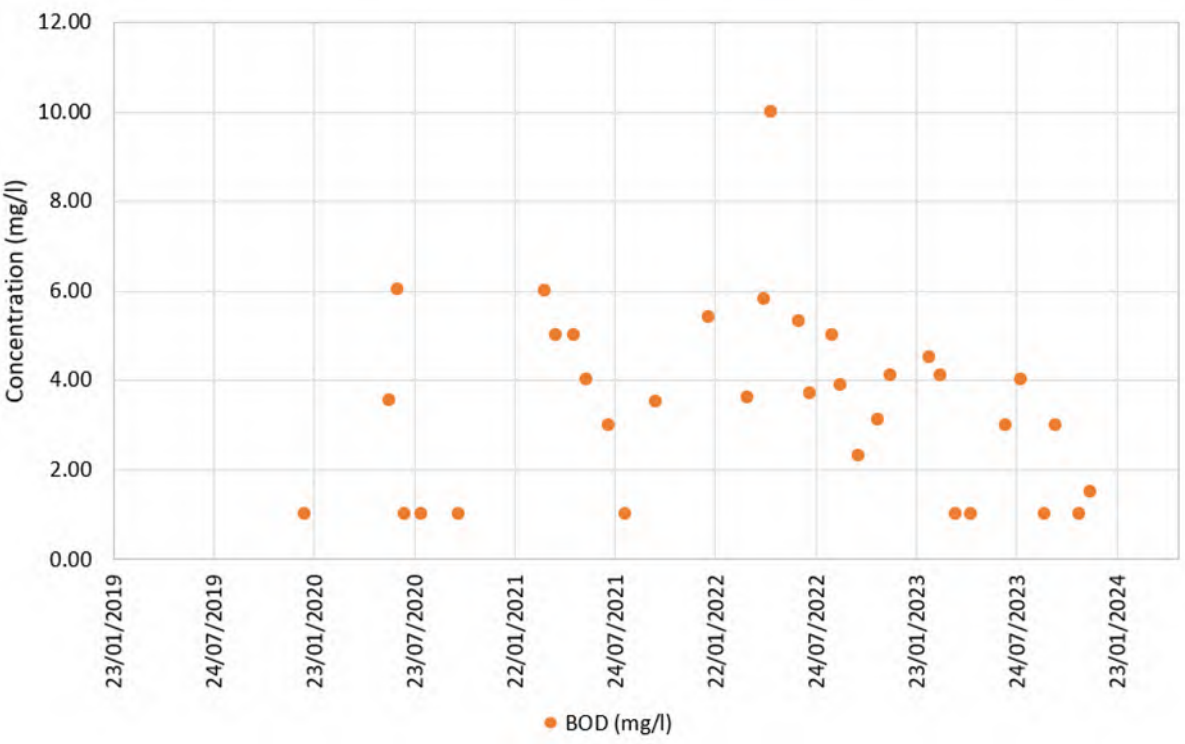

Figure 5-3 - Mortarstown WWTP Effluent BOD Concentrations

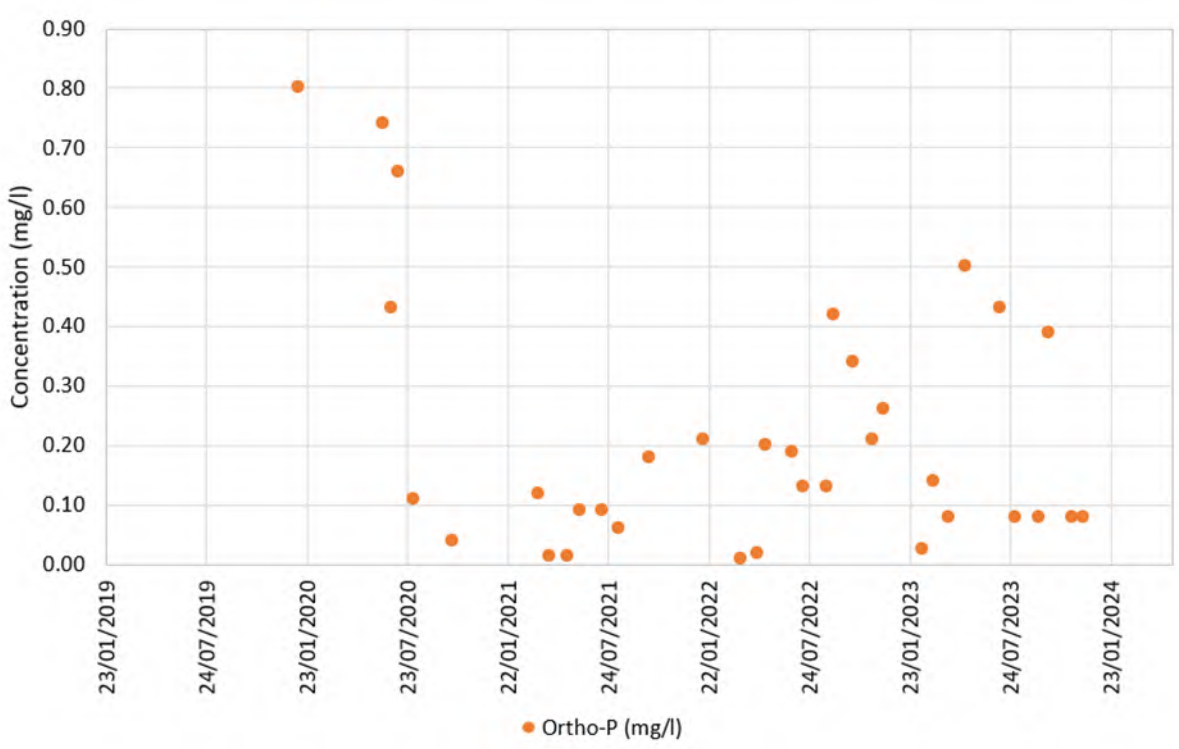

Figure 5-4 - Mortarstown WWTP Effluent Orthophosphate Concentrations

Table 5-2 - Comparison Between Mortarstown WWTP ELVs and Monitored Effluent Quality

Parameter	UWWTD Maximum Permitted Value	Current Mortarstown WWTP ELV	2020-2024 Mortarstown WWTP Treated Effluent Mean
COD (mg/l)	125	125	-
BOD (mg/l)	25	15	3.45
Suspended Solids (mg/l)	35	35	-
pH	--	6 to 9	-
Ammonia (mg/l)	--	2.0	0.11
Orthophosphate (mg/l)	--	0.8	0.216
Total Phosphorus (mg/l)	1.00	1.00	-

6. Water Quality Impact Assessment

The Tiered Assessment approach outlined in Section 1.1 has been applied to the Mortarstown WWTP discharge in the Sections below.

6.1 Tier 0 and 1 Assessments

The Tier 0 and 1 Assessments are initial screening checks to identify substances which require impact assessment. The stages are as follows:

- **Tier 0:** check to see if the effluent is likely to contain a contaminant of concern. If so, check to see if the contaminant is present at levels above the EQS.
- **Tier 1:** Check to see if discharging the contaminant(s) of concern at levels above the EQS are likely to have a significant impact on the receiving waterbody given existing ambient concentrations.

Based on review of the legislative framework in Section 2, substances of concern in Mortarstown WWTP final treated effluent are ammonia, BOD and orthophosphate. Table 6-2 compares average effluent, ambient and EQS concentrations of the substances of concern.

Table 6-1 - Effluent, Ambient and EQS Concentrations of Substances of Concern

Parameter	Mean WWTP Monitored Effluent Concentration	u/s Mean Ambient Concentration (RS14B012310)	Environmental Quality Standard
Ammonia (mg/l)	0.11	0.063	0.065
BOD (mg/l)	3.45	1.805	1.50
Orthophosphate (mg/l)	0.216	0.020	0.035

Table 6-1 shows that effluent concentrations at the existing Mortarstown WWTP for ammonia, orthophosphate and BOD exceed both ambient and EQS concentrations. This will continue at the upgraded WWTP and so these substances will require additional assessment at Tier 2. The pH of the effluent is, and will remain, within the permitted EQS range for rivers and this parameter is therefore screened out at Tier 1.

6.2 Tier 2a Assessment

An initial assessment of the downstream water quality impacts of the Mortarstown WWTP discharge has been made using the simple mass balance approach as set out in Section 1.1.1. Following the methodology of the Uisce Éireann Mass Balance Tool UÉ-AMT-FM-007 downstream mean and 95%ile water quality are predicted based on mean upstream river quality, current mean effluent flow rates and current mean effluent concentrations. The difference between the two calculations is the use of Q_{30} average river flows to predict mean downstream water quality and the Q_{95} low river flow to predict 95%ile downstream water quality. The predicted water quality is compared with observed values in Table 6-2.

Table 6-2 - Downstream Water Quality Statistics predicted using Simple Mass Balance Approach

Parameter	Statistic	Upstream Observed	Downstream Predicted	Downstream Observed
Ammonia (mg/l)	Mean	0.063	0.063	0.069
	95%ile	0.139	0.064	0.202
BOD (mg/l)	Mean	1.805	1.81	1.827
	95%ile	4.100	1.83	4.279
Orthophosphate (mg/l)	Mean	0.020	0.021	0.021
	95%ile	0.049	0.024	0.058

As the ammonia WAC calculations and the BOD WAC calculations are undertaken on the basis of a Notionally Clean approach, the comparison of the downstream predicted concentrations (from the simple Mass Balance WAC Analysis sheet) for ammonia and BOD with the observed data in Table 6-2 is not applicable.

The results in Table 6-2 show that the simple mass balance approach results in a reasonable estimate of the downstream mean water quality for orthophosphate but underestimates the downstream 95%ile water quality for orthophosphate. This is because this approach adopts a simplified representation of upstream river water quality which is the controlling influence on downstream water quality at Mortarstown. As discussed in Section 4, the observed data indicates that the discharges from Mortarstown WWTP have limited impact on downstream water quality under the current scenario.

The simple mass balance approach can be used to calculate ELVs which would give a required downstream water quality corresponding to take-up of the intended percentage of the watercourse's wastewater assimilative capacity (Section 2.4) taking account of the future increases in flow as detailed in Section 5.1. Table 6-3 gives the ELVs required to deliver good indicative quality downstream of the existing discharge point, based on notionally clean upstream water quality (for ammonia and BOD) and using 30% of the available WAC.

Table 6-3 - Required ELVs calculated using Simple Mass Balance Approach

Parameter	Required ELV (Simple Mass Balance Approach), 25-year Design Horizon
Ammonia (mg/l)	2.4
BOD (mg/l)	42.5
Orthophosphate (mg/l)	1.0

The ELVs calculated using the simple mass balance approach are achievable based on biological treatment with nitrification in a WWTP configuration similar to the current WWTP configuration and therefore a Monte Carlo (Tier 2b) analysis is not required Tier 2b Assessment.

6.2.1 Recommended ELVs

Recommended ELVs calculated on the basis of the simple mass balance approach, the UWWTD and the existing Discharge Licence are set out in Table 6-4 below. The calculation is carried out using effluent flows which have been increased by a 30% proportional increase in the dry weather capacity of the WWTP to reflect the increased 25-year design loading. The recommended ELVs are achievable using the existing treatment technology which is a cost-effective and proportionate approach to wastewater management while still providing the required protection of receiving water quality.

Table 6-4 – Recommended ELVs for Mortarstown WWTP

Parameter	ELV
Ammonia	2.0 (in line with the current Discharge Licence)
BOD	25 (in line with UWWTD)
Ortho-P	1.0

The Tier 2 assessment methods show that achievable ELVs can be applied to the discharge and sensitive receptors will not be impacted. Additional analysis of the mixing zone, as would be required in Tier 3 assessment is therefore not required.

7. Summary and Conclusions

Mortarstown WWTP discharges treated wastewater to the River Barrow, 2.2km south of Carlow Town. It is proposed to upgrade the WWTP to increase the treatment capacity of the WWTP; replace equipment and controls nearing the end of their working design life and address deficiencies related to stormwater storage volumes and shallow walled final settlement tanks.

A water quality impact assessment has been carried out in accordance with Uisce Éireann's Technical Guidance[7] to determine the current water quality impacts of the discharge and to calculate the required ELVs for the upgraded WWTP which will protect the environmental from future deterioration in water quality under future loading scenarios, recognising the requirements of the legislative framework.

The water quality of the River Barrow upstream of the WWTP currently fails to comply with good status requirements with respect to BOD and is on the limit with respect to good status requirement for ammonia, therefore the "notionally clean" approach has been applied to BOD and ammonia to account for upstream pressures on water quality and to allow an assessment of the impacts of the WWTP discharges in accordance with the 'Polluter Pays' principle of the Water Framework Directive and in line with current licensing approaches under the WWDA regulations.

The Water Quality Impact Assessment utilised a tiered approach with initial screening at Tiers 0 and 1 followed by a Tier 2a assessment.

The simple mass balance approach was used to calculate ELVs which take an appropriate percentage of the available assimilative capacity in the river, given upstream water quality and the sensitivity of the receiving environment. The

[7] Interim Technical Guidance for Water Impact Assessments (Freshwater) Document No. AMT-GL-028).

calculation is carried out using effluent flows which have been specified to represent the future design capacity of the WWTP. The recommended ELVs calculated using the simple mass balance approach are shown in Table 7-1.

The ELVs determined using the simple mass balance method can be achieved using conventional WWTP technology. It is noted that the ELV for BOD is identified at 25mg/l as per the requirements of the UWWTD.

Table 7-1 – Recommended ELVs for Mortarstown WWTP

Parameter	Recommended Mortarstown WWTP ELVs (mg/l)
Ammonia	2.0 (in line with the current Discharge Licence)
BOD	25 (as per UWWTD)
Ortho-P	1.0

APPENDICES

Appendix A. Annual River Flow Statistics

Annual River Flow Statistics for the River Barrow at OPW New Bridge Barrow Guage Station

Year	Flow (m^3/s)												
	Max	**Min**	**Q_5**	**Q_{10}**	**Q_{20}**	**Q_{30}**	**Q_{40}**	**Q_{50}**	**Q_{60}**	**Q_{70}**	**Q_{80}**	**Q_{90}**	**Q_{95}**
2007	109.4	11.8	67.5	49.5	31.6	22.9	18.2	16.4	15.4	14.2	13.3	12.8	12.5
2008	157.0	8.1	105.9	77.6	56.0	46.8	39.4	33.4	28.3	24.3	19.6	13.7	11.9
2009	189.1	13.2	122.2	85.0	52.1	39.7	31.8	27.6	24.8	22.4	20.4	18.2	17.4
2010	133.5	7.9	75.5	62.8	37.7	30.0	24.9	21.8	18.5	15.5	12.9	11.4	9.9
2011	139.9	8.3	68.4	51.0	36.8	28.2	22.5	17.4	13.6	12.6	11.8	11.0	10.4
2012	107.0	12.6	79.2	62.5	45.5	38.9	33.6	28.5	25.9	22.0	18.9	16.1	14.3
2013	138.5	6.4	64.0	48.6	33.0	24.8	22.1	18.4	14.1	11.1	9.8	8.9	8.1
2014	176.6	7.5	107.7	80.1	62.6	52.9	38.7	29.7	25.2	16.5	12.8	10.3	8.2
2015	196.7	3.7	110.5	70.1	45.1	33.0	25.4	19.8	15.8	11.0	9.7	8.9	8.5
2016	192.9	8.3	96.5	63.8	40.9	26.9	19.7	16.5	14.2	12.4	11.0	10.2	9.2
2017	113.6	7.2	64.6	46.7	31.8	24.4	20.2	16.3	14.3	12.3	11.0	9.5	8.5
2018	133.0	6.7	76.7	64.7	48.4	38.2	26.9	17.8	11.1	9.0	8.2	7.8	7.5
2019	106.8	6.1	74.1	64.2	44.1	32.3	25.7	23.2	19.7	15.5	12.3	9.5	8.5
2020	147.8	10.1	110.6	66.3	50.0	36.9	29.5	24.9	19.1	15.4	13.4	12.1	11.5
2021	134.5	7.5	97.2	65.6	40.2	27.5	22.0	17.1	15.1	12.8	11.2	9.9	8.8
2022	112.7	8.7	87.1	70.8	55.3	40.2	24.1	26.7	21.5	19.5	16.1	12.6	11.4
2023	136.0	11.3	94.4	68.4	53.2	42.0	32.6	31.5	26.3	22.4	17.7	13.6	12.6
2024	128.0	8.5	83.6	64.0	53.2	43.9	37.0	26.7	18.7	13.4	11.9	11.2	10.9
OPW 07-24			85.4	65.3				22.6				10.0	8.8

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