SANITARY AUTHORITY RESPONSE

Name of Sanitary Authority: Donegal County Council

Address: ***County House***
Lifford
County Donegal

Name of Facility: United Fish Industries Limited ***IPPC Reg. No: P0416-03***

Address: ***Donegal Road***
Killybegs
County Donegal

Consent: Indicate Yes to one of the following statements:

Consent granted subject to the consent conditions outlined below.	Yes
Consent granted without conditions.	
Consent refused [Note 1] **.**	

Note 1 Where it is proposed to refuse permission the reasons for the refusal should be clearly outlined in the response.

GENERAL CONSENT CONDITIONS	**Condition to be Included** *(Yes/No)*
1. The licensee shall permit authorised persons, of the Agency and Sanitary Authority, to inspect, examine and test, at all reasonable times, any works and apparatus installed in connection with the process effluent and to take samples of the process effluent.	Yes
2. The licensee shall at no time discharge or permit to be discharged into the sewer any liquid matter or thing that is or may be liable to set or congeal at average sewer temperature or is capable of giving off any inflammable or explosive gas or any acid, alkali or other substance in sufficient concentration to cause corrosion to sewer pipes, penstock and sewer fittings or the general integrity of the sewer.	Yes

ADDITIONAL GENERAL CONSENT CONDITIONS **In respect of discharges or emissions to sewers, in accordance with Section 99E of the Environmental Protection Agency Acts 1992 and 2003** ***(Specify, if required)***
This consent covers 3 stages which take into account: Stage (1) The current situation: Stage (2) The immanent development of the new Killybegs outfall and industrial sewer network, combined with proposed associated changes to the discharge arrangements of the licensee in 2012: Stage (3) Proposed increases in production volumes by the licensee which would result in increased discharge loads and volume in 2016.
It should be noted that stage (3) of these proposed changes will be dependant on a review of the current Killybegs WWDA held by Donegal County Council. In preparation for this review Donegal County Council has undertaken a rerun of the computerised dispersion model used in the original application which takes into account tidal current speeds and the deeper actual location of the outfall point than was proposed in the original application. No change to the current mixing zone is proposed. The full results of this rerun model will be part of any review of the current WWDA sought however a copy of the output has been included as a basis for the consent conditions proposed for Stage (3). The conclusions of the model, which is a more sophisticated model that was used in the initial Killybegs WWDA application, shows that the total load of DIN including Ammonia applied for by UFI is somewhat less than 25% of the projected capacity of the mixing zone as defined in the current licence. It should be noted that this stage will not be reached until 2016 by which time actual monitoring will have taken place to verify the accuracy of the model. However given the relatively small proportion of the projected DIN capacity being sought to allow this stage to proceed, it is considered to be well within any difference that may be found between the projected and actual measured DIN capacity.

Limit Values for Process Effluent to Sewer

Schedule B: Emission Limits Stage 1

Emission point reference no: SE1

Emission to ***(sewer description):*** Industrial Sewer

Volume to be emitted: Maximum in any one day: 1,200 m^3
Maximum rate per hour: ____________ m^3

Parameter *(delete parameters which are not applicable)*	**Emission Limit Value**	
	Daily Mean Concentration (mg/l)	**Daily Mean Loading (kg/day)**
BOD		1,200
COD		
Suspended Solids	100	
pH	6-9	
Temperature Degrees C	25	
ADDITIONAL PARAMETERS ***(if required)***		
Ammonia		60
DIN		110
Total Phosphorus	100	
Fats Oils Greases	15	
Detergents	100	

Limit Values for Process Effluent to Sewer

Schedule B: Emission Limits Stage 2

Emission point reference no: SE1

Emission to *(sewer description):* Industrial Sewer

Volume to be emitted: Maximum in any one day: 1,500 m^3
Maximum rate per hour: ________ m^3

Parameter *(delete parameters which are not applicable)*	**Emission Limit Value**	
	Daily Mean Concentration (mg/l)	**Daily Mean Loading (kg/day)**
BOD		3,500
COD		
Suspended Solids	100	
pH	6-9	
Temperature Degrees C	30	
ADDITIONAL PARAMETERS *(if required)*		
Ammonia		300
DIN		350
Total Phosphorus	100	
Fats Oils Greases	100	
Detergents	100	

Limit Values for Process Effluent to Sewer

Schedule B: Emission Limits Stage 3

Emission point reference no: SE1

Emission to ***(sewer description):*** Foul Sewer

Volume to be emitted: Maximum in any one day: 2000 m^3
Maximum rate per hour: ______ m^3

Parameter ***(delete parameters which are not applicable)***	**Emission Limit Value**	
	Daily Mean Concentration (mg/l)	**Daily Mean Loading (kg/day)**
BOD		5750
COD		
Suspended Solids		150
pH	6-9	
Temperature Degrees C	30	
ADDITIONAL PARAMETERS ***(if required)***		
Ammonia		540
DIN		590
Total Phosphorus	100	
Fats Oils Greases	100	
Detergents	100	

Frequency of Monitoring Process Effluent to Sewer

Schedule C

Emission point reference no: SE1

Parameter *(delete parameters which are not applicable)*	**Monitoring Frequency (e.g. monthly, quarterly, annually)**	**Sample Type** *(grab, composite)*
Flow to sewer	Continuous	On Line Flow Meter/recorder
Temperature	Continuous	On Line Temp Probe/recorder
pH	Continuous	On Line pH Probe/recorder
BOD	Weekly	24 hr flow proportionate composite sampler
COD		
Suspended Solids	Weekly	24 hr flow proportionate composite sampler
ADDITIONAL PARAMETERS ***(if required)***		
Ammonia	Weekly	24 hr flow proportionate composite sampler
DIN	Weekly	24 hr flow proportionate composite sampler
Nitrate	Monthly	24 hr flow proportionate composite sampler
Total Phosphorus	Monthly	24 hr flow proportionate composite sampler
Fats Oils Greases	Monthly	24 hr flow proportionate composite sampler
Detergents	Bi Monthly	24 hr flow proportionate composite sampler

Signed on behalf of Sanitary Authority: [signature] 30/9/11

Section 99E of the Environmental Protection Agency Acts 1992 and 2003

99E.- (1) Where the Agency proposes to grant a licence (including a revised licence) which involves a discharge of any trade effluent or other matter (other than domestic sewage or storm water) to a sewer, it shall obtain the consent of the sanitary authority in which the sewer is vested, or by which the sewer is controlled, to such a discharge being made.

(2) Where consent is sought in accordance with subsection (1), the Agency may specify a period (which period shall not in any case be less than 4 weeks from the date on which the consent is sought) within which the consent may be granted subject to, or without, conditions or refused; any consent purporting to be granted (whether subject to or without conditions) after the expiry of that period, or any decision given purporting to refuse consent after that expiry, shall be invalid and in those circumstances the Agency may proceed to grant the licence concerned as if the requirements of subsection (1) had been satisfied.

(3) Subject to subsection (4), a consent under subsection (1) may be granted subject to or without conditions and if it is granted subject to conditions the Agency shall include in the licence or revised licence concerned conditions corresponding to them or, as the Agency may think appropriate, conditions more strict than them.

(4) The conditions that may be attached to a consent by a sanitary authority under this section are the following and no other conditions, namely conditions-

(a) relating to-

(i) the nature, composition, temperature, volume, level, rate, and location of the discharge concerned and the period during which the discharge may, or may not, be made,

(ii) the provision, operation, maintenance and supervision of meters, gauges, manholes, inspection chambers and other apparatus and other means for monitoring the nature, extent and effect of emissions,

(iii) the taking and analysis of samples, the keeping of records and furnishing of information to the sanitary authority,

(b) specifying a date not later than which any conditions attached under this section shall be complied with,

(c) relating to, providing for or specifying such other matter as may be prescribed.

(5) A sanitary authority may request the Agency to review a licence or revised licence to which this section relates-

(a) at intervals of not less than 3 years from the date on which the licence or the revised licence is granted, or

(b) at any time with the consent, or on the application, of the person making, causing or permitting the discharge, or

(c) at any time if-

(i) the sanitary authority has reasonable grounds for believing that the discharge authorised by the licence or revised licence is, or is likely to be, injurious to public health or is likely to render the waters to which the sewer concerned discharges unfit for use for domestic, commercial, industrial, fishery (including fish-farming), agricultural or recreational uses or is, or is likely to be otherwise, a serious risk to the quality of the waters,

(ii) there has been a material change in the nature or volume of the discharge,

(iii) there has been a material change in relation to the waters to which the sewer concerned discharges, or

(iv) further information has become available since the date on which the licence or revised licence was granted relating to polluting matter present in the discharge concerned or relating to the effects of such matter, and the Agency shall consider and may comply with such request and shall have regard to any submission on the matter received from the sanitary authority.

(6) In this section, a reference to a sanitary authority shall be construed as including a reference to any person acting on behalf or jointly with a sanitary authority.

AQUAFACT

DRUMBANNAN OUTFALL
DIN AND BOD STUDY

Prepared by

AQUAFACT International Services Ltd

On behalf of

Jennings O'Donovan
Consulting Engineers

September 2011

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Table of Contents

1. INTRODUCTION

AQUAFACT International Services Limited was commissioned by Jennings O'Donovan Consulting Engineers to determine if there could be any additional capacity for Dissolved Inorganic Nitrogen (DIN) and Biological Oxygen Demand (BOD) at the Drumbannan outfall in Killybegs Harbour Outfall, Co. Donegal. The study employed the U.S. E.P.A's VISUAL PLUMES (VP) model to carry out the environmental design evaluation. The location of the outfall diffuser system is shown in Figure 1.1. Part of this study also included the collection of current direction and velocity data at the outfall site over a Spring/Neap tidal cycle using an acoustic Doppler current profiler (ADCP). Water chemistry samples were collected by Donegal around the mouth of Killybegs Harbour and within the harbour in the vicinity of the Bungosteen River. These data were used as input to the model as background levels.

Information on the Visual Plumes model is given in Chapter 2 and further details can be found in Frick (2004). Details of all the relevant environmental and hydrodynamic data required as input to the model are detailed in Chapter 3. Results of the model simulations are presented in Chapter 4. Conclusions are presented in Chapter 5.

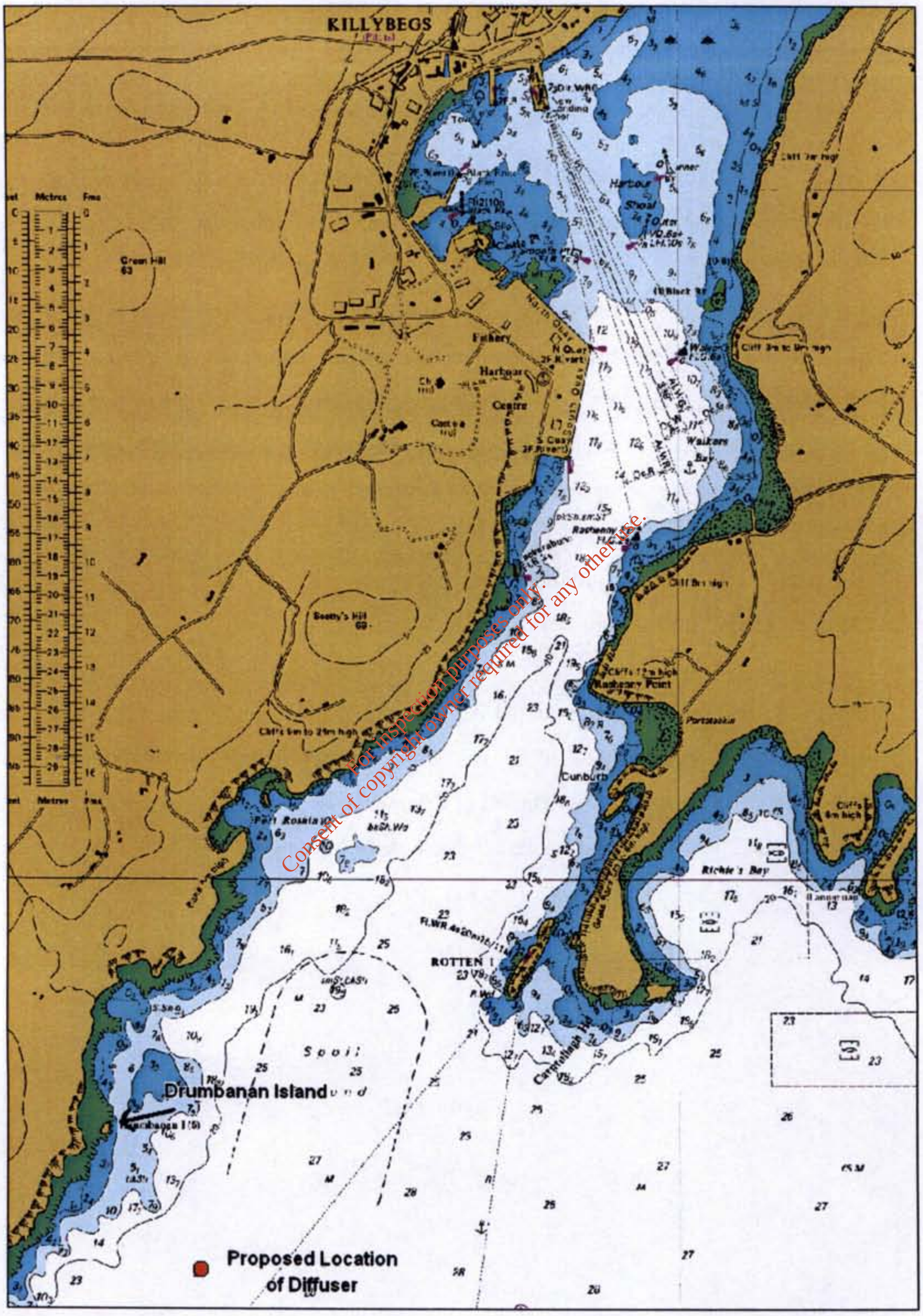

Figure 1.1: *Plan view of Killybegs Harbour showing proposed location of outfall diffuser*

2. VISUAL PLUMES MODEL

The US Environmental Protection Agency has a history of developing plume models and providing technical assistance. The Visual Plumes model (VP) is a recent addition to the public-domain models available on the EPA Center for Exposure Assessment Modeling (CEAM) web page. The Windows-based VP adapts, modifies and enhances the earlier DOS-based PLUMES with a new interface, models and capabilities. VP is a public platform for mixing zone models designed to encourage the continued improvement of plume theory and models by facilitating verification and inter-model comparison. VP is capable for reasonably one-dimensional estuaries, to estimate background concentrations due to tidal re-circulation of previously contaminated receiving water. This capability depends on the optional linkage to time-series input files that enables VP to simulate mixing zone and far-field parameters for long periods (see Frick, 2004).

2.1 Model Theory

The mixing behaviour of any wastewater discharge is governed by the interplay of ambient conditions in the receiving water body and by the discharge characteristics.

The ambient conditions in the receiving water body, be it stream, river, lake, reservoir, estuary or coastal waters, are described by the water body's geometric and dynamic characteristics (Jirka *et al.*, 1996).

Important geometric parameters include plan shape, vertical cross-sections, and bathymetry, especially in the discharge vicinity. Dynamic characteristics are given by the velocity and density distribution in the water body, again primarily in the discharge vicinity.

In many cases, these conditions can be taken as steady-state with little variation because the time scale for the mixing processes is usually of the order of minutes up to perhaps one hour. In some cases, notably tidally influenced flows, the ambient conditions can be highly transient and the assumption of steady-state conditions may be inappropriate. In this case, the effective dilution of the discharge plume may be reduced relative to that under steady state conditions.

The discharge conditions relate to the geometric and flux characteristics of the submerged outfall installation. For a single port discharge, the port diameter, its elevation above the bottom and its orientation provide the geometry, for multi-port diffuser installations, the arrangement of the individual ports along the diffuser line, the orientation of the diffuser line, and construction details represent additional geometric features. The flux characteristics are given by the effluent discharge flow rate, by its momentum flux and by its buoyancy flux. The buoyancy flux represents the effect of the relative density difference between the effluent discharge and ambient conditions in combination with the gravitational acceleration. It is a measure of the tendency for the effluent flow to rise (i.e. positive buoyancy) or to fall (i.e. negative buoyancy).

The hydrodynamics of an effluent continuously discharging into a receiving water body can be conceptualised as a mixing process occurring in two separate regions. In the first region, the initial jet characteristics of momentum flux, buoyancy flux, and outfall geometry influence the jet trajectory and mixing. This region is referred to as the "near-field region", and encompasses the buoyant jet flow and any surface, bottom or terminal layer interaction. In this near-field region, outfall designers can usually affect the initial mixing characteristics through appropriate manipulation of design variables.

As the turbulent plume travels further away from the source, the source characteristics become less important. Conditions existing in the ambient environment will control trajectory and dilution of the turbulent plume through buoyant spreading motions and passive diffusion due to ambient turbulence. This region is referred to as the "far-field region". The distinction between near-field and far-field regions is made purely on hydrodynamic grounds. It is unrelated to any regulatory mixing zone definitions.

2.2 Hydrodynamic Mixing Processes

The VP model simulates a number of different hydrodynamic mixing processes in order to compute the dilution characteristics of an effluent discharge. The distinction between near-field and far-field regions can also be applied to these hydrodynamic mixing processes.

2.2.1 Near-Field Processes

Three important types of near-field processes are submerged buoyant jet mixing, boundary interactions and surface buoyant jet mixing.

Submerged Buoyant Jet Mixing: The effluent flow from a submerged discharge port provides a velocity discontinuity between the discharged fluid and the ambient fluid causing a shearing action. The shearing flow breaks rapidly down into a turbulent motion. The width of the zone of high turbulence intensity increases in the direction of the flow by entraining more of the outside, less turbulent fluid into this zone. In this manner any internal concentrations of the discharge flow become diluted by the entrainment of ambient water. Conversely, it could be said that both fluid momentum and pollutants become gradually diffused into the ambient field.

Boundary Interaction Processes: Ambient water bodies always have vertical boundaries. These include the water surface and the bottom, but in addition, "internal boundaries" may exist at pycnoclines. Boundary interaction processes provide a transition between the buoyant jet mixing process in the near-field and between buoyant spreading and passive diffusion in the far-field. They can be gradual and mild, or abrupt leading to vigorous transition and mixing processes.

Surface Buoyant Jet Mixing: Positively buoyant jets discharged horizontally along the water surface from a laterally entering channel or pipe bear some similarities to the more classical submerged buoyant jet. For a relatively short initial distance, the effluent behaves like a momentum jet spreading both laterally and vertically due to turbulent mixing. After this stage, vertical entrainment becomes inhibited due to buoyant damping of the turbulent motions, and the jet experiences strong lateral spreading. During stagnant ambient conditions, ultimately a reasonably thin layer may be formed at the surface of the receiving water.

2.2.2 Far-Field Processes

Far-field mixing processes are characterised by the longitudinal advection of the mixed effluent by the ambient current velocity.

Buoyant Spreading Processes: These are defined as the horizontally transverse spreading of the mixed effluent flow while it is being advected downstream by the ambient current. Such spreading processes arise due to the buoyant forces caused by the density difference of the mixed flow relative to the ambient density. They can be effective transport mechanisms that can quickly spread a mixed effluent laterally over large distances in the transverse direction, particularly in cases of strong ambient stratification. In this situation, effluent of considerable vertical thickness at the terminal level can collapse into a thin but very wide layer unless this is prevented by lateral boundaries. If the discharge is non-buoyant, or weakly buoyant, and the ambient is unstratified, there is no buoyant spreading region in the far-field, only a passive diffusion region.

Passive Ambient Diffusion Process: The existing turbulence in the ambient environment becomes the dominating mixing mechanism at sufficiently large distances from the discharge point. In general, the passively diffusing flow grows in width and thickness until it interacts with a lateral boundary. The strength of the ambient diffusion mechanism depends on a number of factors relating mainly to the geometry of the ambient shear flow and the amount of ambient stratification. In the context of classical diffusion theory, gradient diffusion processes in the bounded flows of rivers or narrow estuaries can be described by constant diffusivities in the vertical and horizontal direction that depend on turbulent intensity and on channel depth or width as the length scales. In contrast, wide, "unbounded" channels or open coastal areas are characterised by plume size dependent diffusivities leading to accelerating plume growth described, for example, by the "4/3 law" of diffusion. In the presence of a stable ambient stratification, the vertical diffusive mixing is generally strongly damped.

2.3 Model Application

As stated previously, the environmental design of a diffuser focuses on the hydrodynamic mixing of the discharge effluent with the receiving water. The VP model achieves this aim by computing the discharge plume centreline dilution and the plume geometry with respect to distance from the release point based on the hydrodynamic and geometric characteristics of the discharge and the ambient conditions of the receiving waters. Figure 2.1 presents a flow chart which shows the main input variables, computational components and output parameters of the VPmodel.

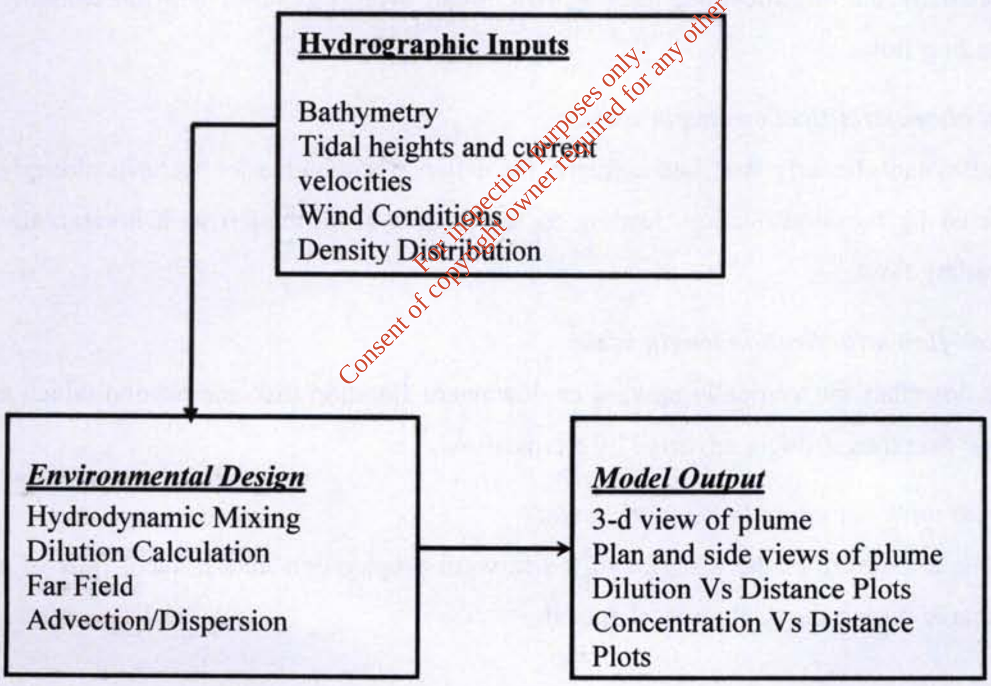

Figure 2.1: *Flow chart showing main inputs and components of the environmental design process for a diffuser.*

The program computes different length scales which represent important dynamic measures about the relative influence of certain hydrodynamic processes, such as buoyancy, jet momentum, advection and passive diffusion, on effluent mixing. The computed length scales are:

- ***Slot jet plume transition length scale:***

  This is the distance at which the transition from jet to plume behaviour takes place in a stagnant, uniform ambient region.

- ***Slot jet cross-flow length scale:***

  In the presence of a cross-flow, the distance of the transverse (i.e. across ambient flow) jet penetration beyond which the jet is strongly deflected by the cross-flow.

- ***Slot jet stratification length scale:***

  In a stagnant, linearly stratified ambient, the distance at which a jet becomes strongly affected by the stratification, leading to terminal layer formation with horizontally spreading flows.

- ***Slot plumestratification length scale:***

  In a stagnant, linearly stratified ambient, the distance at which a jet becomes strongly affected by the stratification, leading to terminal layer formation with horizontally spreading flows.

- ***Cross-flow stratification length scale:***

  This describes the vertically upward or downward flotation distance beyond which a plume becomes strongly advected by a cross-flow.

- ***Jet to unsteady cross-flow length scale:***

  This is a measure of the distance of the forward propagation into ambient flow of a discharge during the tidal reversal episode.

These calculated length scales are subsequently used to identify the generic flow class upon which the hydraulic simulations will be based. The hydraulic simulation characteristics for these flow classes are pre-programmed in VP and were derived from theoretical studies and/or experimental data (Jirka *et. al.*, 1996). This approach allows efficient flow prediction to be achieved, incorporating the particular characteristics of the discharge and the ambient water conditions.

Output from the VP simulations consists of: the location of the plume centreline (x, y, z), hydrodynamic average dilution, average pollutant concentration, plume top-hat thickness (measured vertically from the sea bed), plume top-hat half-width (measured horizontally from the shoreline) and cumulative time of travel for the different mixing zones and for the specified region of interest or until the time of tidal reversal whichever has the least time of travel.

3. MODEL INPUT DATA

The input data required by VP prior to each discharge simulation consist of five main sections. These include data pertaining to the bathymetry of the seabed at the discharge location, the ambient conditions of the receiving waters, details of the diffuser configuration, the effluent and discharge characteristics and specifications regarding the regulatory mixing zone. The input datasets relating to each of the above mentioned sections are detailed below.

3.1 Bathymetry

VP requires that the actual cross-section of the ambient water body be described by a rectangular channel that may be bounded laterally or unbounded. In order to determine this, a cross-section of the bay coinciding with the location of the diffuser was examined and the average depth was calculated to be 25 to 27m and the local depth to be 29m at LAT. (i.e. -31m O.D. Malin).

The channel was classified as unbounded. Though the discharge is located close to the left bank, (approximately 380m), the other bank is far enough away as to render interaction of the plume with the right bank extremely unlikely.

3.2 Ambient Conditions

Salinity measurements at the proposed site indicate that density stratification was not significant during the summer period with the water having an ambient density of 1025 kg/m^3 (AQUAFACT, 1998).

Current velocities at the proposed site are very weak and act in a predominantly rectilinear direction (i.e. parallel to the coastline). Both ebb and flood flows are of equal strength. The mean maximum neap tide velocity is 0.035 m/s and the mean maximum spring tide velocity is 0.075 m/s. The annual mean spring and neap tidal ranges are 3.5 m and 1.5 m respectively.

3.3 Diffuser Type and Configuration

The diffuser manifold is arranged normal to the ambient flow direction. The horizontal and vertical orientations of the diffuser ports are parallel to the manifold. The port centrelines are located 500 mm above the bed. The start of the diffuser line is located approximately 380 m from the western shoreline. The riser port diameters are 200mm fitted with Redvalve Tideflex check valves.

Tideflex check valves were included in the design of the diffuser. The check valves have the effect of improving the distribution of flow between the riser ports. They also ensure that no back flow occurs within the ports. Flow characteristics for the Tideflex check valves in terms of flow rate versus head loss, jet velocity and effective open area were obtained from the Red Valve Company Inc. for the 200 mm CN 297 check valve. The diameter of the port with the Tideflex valve fitted varied depending on the discharge rate and back pressure.

Table 3.1 TIDEFLEX Valve 200mm HC-297 hydraulic characteristics

Total number of Ports	Total Flow (litres/sec)	Flow (litres/sec)	Jet Velocity (m/s)	Total Headloss at valve (m)	Effective Area (cm2)
5	50	10	1.8	0.2	55.1
	100	20	2.6	0.3	76.9
	283.1	56.6	4.6	1.1	123.1

3.3.1 Proposed Design by BAM

The design of the outfall diffuser system as supplied by BAM is presented in Figure 3.2, and can be described as a single manifold diffuser design of length 24m with 5 No. risers per manifold spaced at 6m centres. Design loadings for the diffuser design are detailed below: The diffuser line is aligned perpendicular to the weak ambient tidal current with horizontal diffuser jets orientated along the pipeline and discharging normal to flow. The local depth is set at -31m O.D. Malin as specified.

The following Effluent Hydraulic Load Scenarios were investigated:

Load Scenario	No. Of Port	Discharge (m3/hr)	horizontal Jet Velocity (m/s)	Effluent BOD mg/litre	Effluent DIN mg/litre
1	5	225	2.05	3000	120.7
2	5	1019	4.59	663	26.6
3	5	424	2.86	1593	64.1
4	5	623	3.52	1083	43.6
5	5	821	4.08	822	33.1

Table 3.2: Diffuser Hydraulic Discharge Scenarios Examined using EPA Visual Plumes Model.

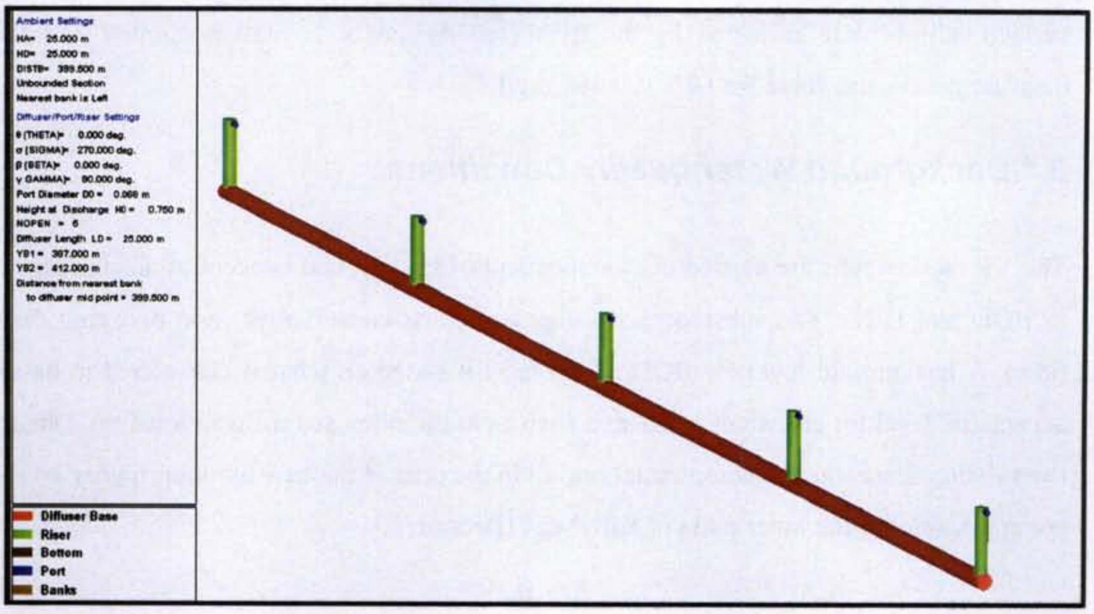

***Figure 3.1:** Diffuser Design supplied by BAM.*

3.3 Effluent and Discharge Characteristics

Laboratory tests carried out by Aqualab Ltd. (AQUAFACT, 1998) determined a mean effluent density of 1001 kg/m^3.

Based on the design high and low flow loadings specified by JOD and taking into account the VP schematisation of the diffusers, the discharge BOD concentrations and hydraulic loads as defined to the VP simulations are defined in Table 3.1.

3.4 Mixing Zone and Environmental Quality Standards

A mixing zone of 200 metres radius from the outfall centre was chosen beyond which the effluent concentration must satisfy environmental quality standards, (EQS). The extent of the mixing zone in relation to the study area is shown in Figure 3.2.

The EPA Directive on Water Quality Standards in Irish Waters (EPA, 1997) stipulates that the maximum permissible level of BOD is 4.0mg/l. The water quality objectives outside of the 200m initial mixing zone are 4 mg/l BOD and 0.3mg/l ammonia. Using surface salinity data collected by the EPA (see Appendix 1, Station number 310 for measurements), the value for DIN is 0.494 mg/l.

3.5 Background Water quality Conditions

The VP models runs are carried out independent of background concentrations in respect to BOD and DIN. The substances are also treated as conservative (non decaying over time). A background level for BOD of 1.0 mg/l is based on what is considered to be an acceptable level for sea water in an area such as at the proposed diffuser location. Due to the existing domestic and commercial outfall in the area of the new harbour, higher levels are applicable for the inner parts of Killybegs Harbour.

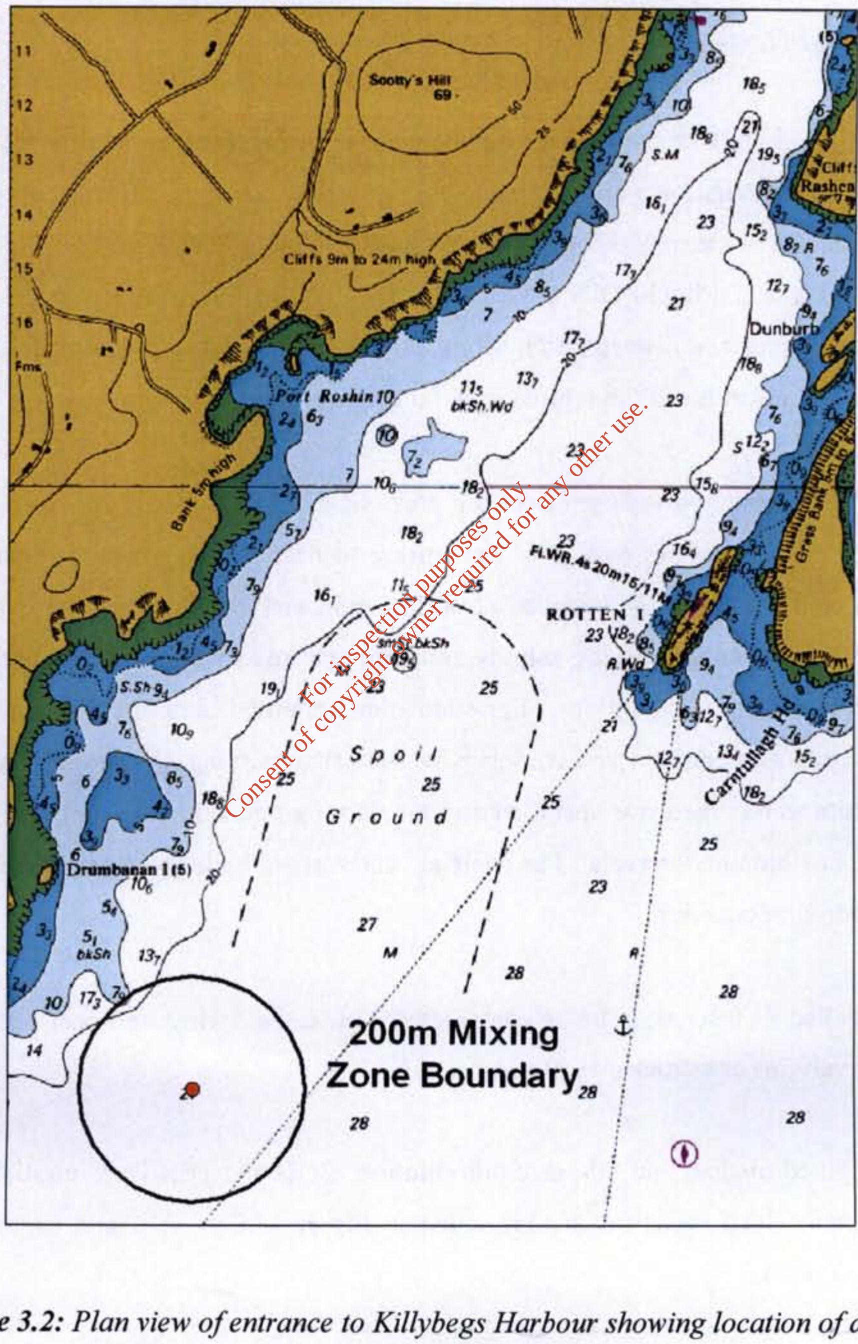

Figure 3.2: *Plan view of entrance to Killybegs Harbour showing location of diffuser near Drumbannan Island and the 200 m radius mixing zone.*

4. MODEL SIMULATIONS AND RESULTS

4.1 Model Results

The results of all five hydraulic load simulations are presented in this section. The hydraulic load scenarios were chosen to represent the range of effluent concentrations from minimum to maximum for the design load of 675 kg/hour BOD (663mg/l to 3000 mg/l BOD) and 27.15kg/hr DIN (33.1mg/l to 120.7mg/l). The EPA VP model was used to predict the surface concentration along the centreline of the plume at the nearfield Mixing Zone and at the 200m regulatory mixing Zone.

The EPA VP model was chosen over the previous CORMIX model due to its ability to use surveyed times series over a 14 day spring to neap cycles (refer to Figure 4.1) of current speed and direction sampled at surface mid and bottom and tidal depth. This model also includes for varying salinity and temperature as well as decay (bacteria) and variation in discharge conditions. For simulations reported here, the effluent discharge was specified as a constant and conservative (non time varying) discharge. Salinity and temperature as recorded was specified and the varying tide velocities and tidal height as recorded in 10minute intervals. The nearfield and farfield hydrodynamics were set to the surveyed hydrodynamics.

The modelled diffuser was the as-constructed 24m Long 5 riser and port diffuser with Tideflex valve as constructed by BAM.

The computed median and 90-percentile dilution, BOD and DIN concentrations for the five hydraulic load scenarios are presented in Figures 4.2 to 4.16 and summarised in Tables 4.1 and 4.2.

4.2 Discussion

At the 200m Regulatory Mixing Zone the simulation results give a median BOD concentration (for the spring – neap 14 day simulation period) for a design load of 675mg/l BOD of 1.65 to 2.25 mg/l depending on the combination of hydraulic flow and effluent BOD Concentration and an average median concentration of 1.91mg/l BOD for the range of effluent flow combinations. The simulation results give a 90-percentile BOD concentration for a design BOD load of 2.08 to 3.17 mg/l and the average 90-percentile concentration of 2.53mg/l BOD for the range of effluent flow combinations.

At the 200m Regulatory Mixing Zone the simulation results give a median concentration (for the spring – neap 14 day simulation period) for a design load of 27.15mg/l DIN of 0.066 to 0.091 mg/l depending on the combination of effluent hydraulic flow and DIN concentration and an average median concentration of 0.077mg/l DIN for the range of effluent flow combinations. The simulation results give a 90-percentile DIN concentration of 0.084 to 0.128 mg/l and the average 90-percentile concentration of 0.102mg/l DIN for the range of effluent flow combinations.

Allowing for a background 90-percentile BOD concentration of 1.0mg/l, the dilution simulation results show that the combined outfall plume and ambient background BOD give a 90percentile concentration of 3.53mg/litre BOD at the 200m regulatory Mixing Zone boundary which is within 0.47 mg/l of the EQS limit of 4mg/l BOD. .

BOD (mg/l) 90percentile concentration		
Effluent Discharge Scenarios (1 to 5)	200m Regulatory Mixing Zone Outfall only mg/l BOD	200m Regulatory Mixing Zone Outfall + Background mg/l BOD
1. 0.063m3/s @ 3000mg/l BOD	3.17	4.17
2. 0.283m3/s @ 662.5mg/l BOD	2.08	3.08
3. 0.118m3/s @ 1593 mg/l BOD	2.74	3.74
4. 0.173m3/s @ 1083 mg/l BOD	2.44	3.44
5. 0.228m3/s @ 822 mg/l BOD	2.24	3.24
	2.53	**3.53**

Allowing for a background median DIN concentration of 0.165 mg/l, the dilution simulation results show that the combined outfall plume and ambient background DIN give a median DIN concentration of 0.242 mg/litre at the 200m regulatory Mixing Zone boundary.

DIN (mg/l) Median concentration		
Effluent Discharge Scenarios (1 to 5)	200m Regulatory Mixing Zone Outfall only mg/l DIN	200m Regulatory Mixing Zone Outfall + Background mg/l DIN
1. 0.063m3/s @ 120.7mg/l DIN	0.091	0.256
2. 0.283m3/s @ 26.6mg/l DIN	0.066	0.231
3. 0.118m3/s @ 64.1mg/l DIN	0.081	0.246
4. 0.173m3/s @ 43.6mg/l DIN	0.075	0.240
5. 0.228m3/s @ 33.1mg/l DIN	0.070	0.235
	0.077	**0.242**

Table 4.1 Median Dilution and Water Quality Results for recorded 2 week spring-neap simulation

Load Scenario	Hydraulic load m3/s	Effluent				Dilution		BOD (mg/l)		DIN (mg/l)	
		BOD load kg/hr	BOD mg/l	DIN Load Kg/hr	DIN mg/l	Nearfield Mixing Zone	200m Reg Mixing Zone	Nearfield Mixing Zone	200m Reg Mixing Zone	Nearfield Mixing Zone	200m Reg Mixing Zone
1	0.063	675	3000	27.15	120.7	934.5	1331.0	3.21	2.25	0.129	0.091
2	0.283	675	663	27.15	26.6	277.3	401.5	2.39	1.65	0.096	0.066
3	0.1177	675	1593	27.15	64.1	542.8	787.3	2.93	2.02	0.118	0.081
4	0.173	675	1083	27.15	43.6	399.5	579.6	2.71	1.87	0.109	0.075
5	0.228	675	822	27.15	33.1	324.5	469.3	2.53	1.75	0.102	0.070
						495.7	713.7	**2.76**	**1.91**	**0.111**	**0.077**

Table 4.2 90-percentile Dilution and Water Quality Results for recorded 2 week spring-neap simulation

Load Scenario	Hydraulic load m3/s	Effluent				Dilution		BOD (mg/l)		DIN (mg/l)	
		BOD load kg/hr	BOD mg/l	DIN Load Kg/hr	DIN mg/l	Nearfield Mixing Zone	200m Reg Mixing Zone	Nearfield Mixing Zone	200m Reg Mixing Zone	Nearfield Mixing Zone	200m Reg Mixing Zone
1	0.065	675	3000	27.15	120.7	651.6	946.1	4.60	3.17	0.185	0.128
2	0.283	675	663	27.15	26.6	223.7	318.4	2.96	2.08	0.119	0.084
3	0.1177	675	1593	27.15	64.1	404.0	581.7	3.94	2.74	0.159	0.110
4	0.173	675	1083	27.15	43.6	308.2	443.8	3.51	2.44	0.141	0.098
5	0.228	675	822	27.15	33.1	257.3	367.7	3.20	2.24	0.129	0.090
						369.0	**531.5**	**3.64**	**2.53**	**0.147**	**0.102**

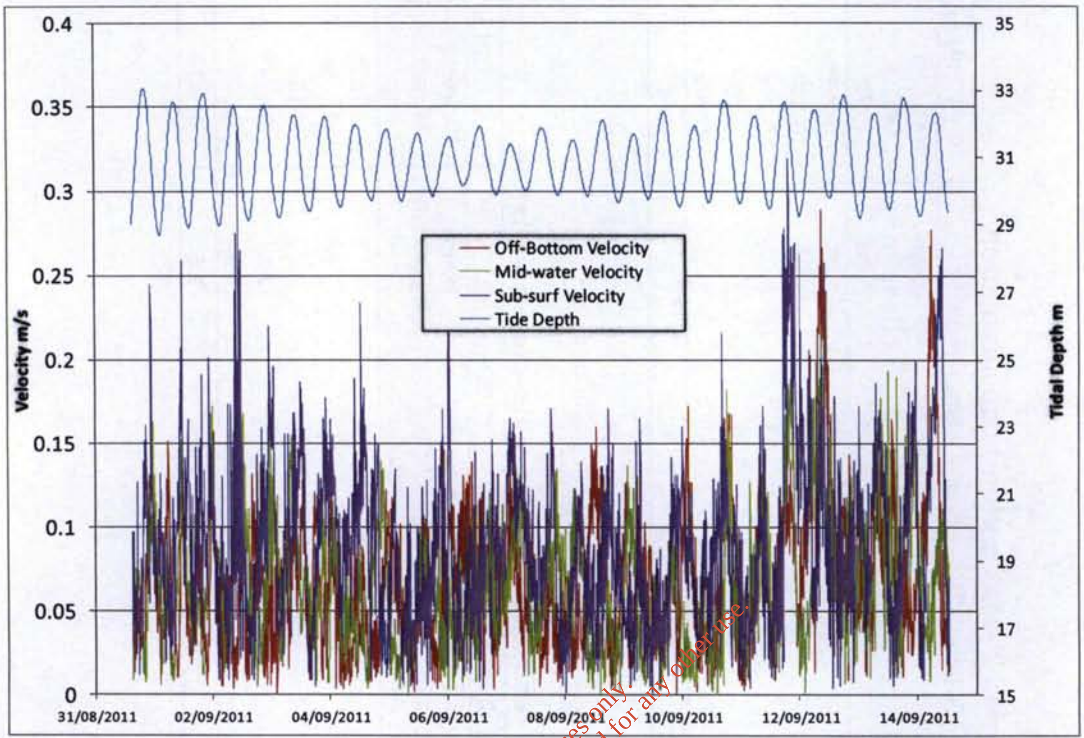

Figure 4.1 Recorded Current Speeds and tidal Depths at Outfall Location (31-Aug-11 to 14-Sept-11)

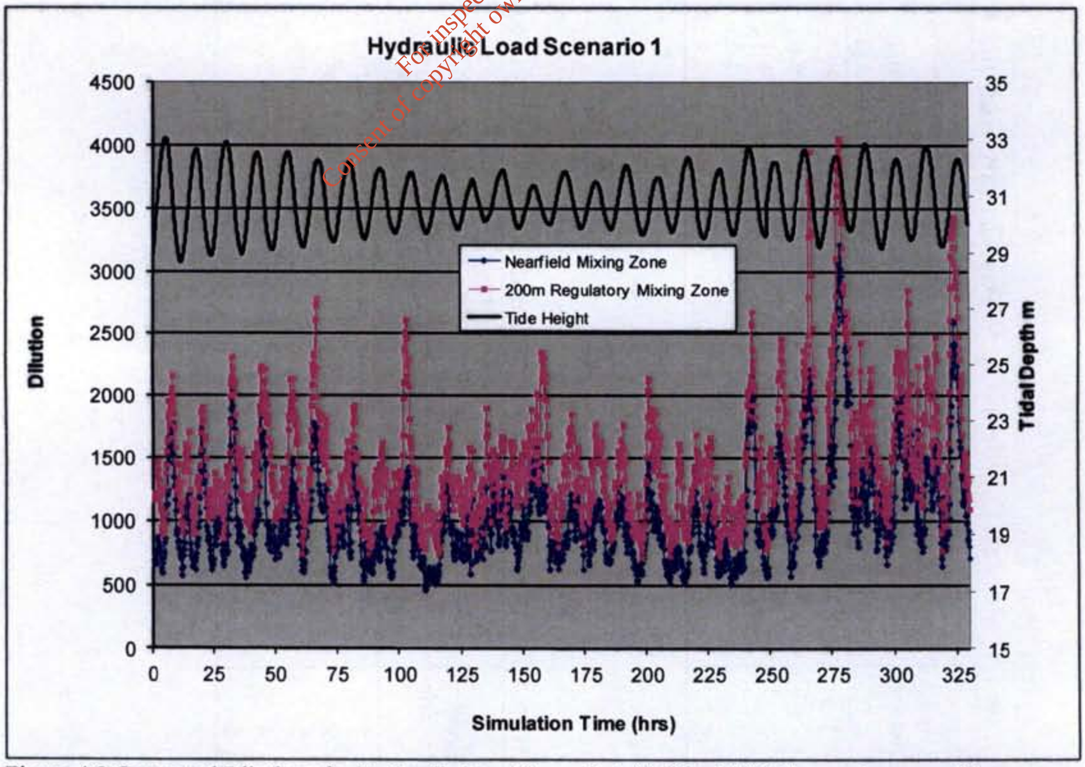

Figure 4.2 Computed Dilutions for Hydraulic Load Scenario 1 (0.063m3/s) 14day spring-neap tides

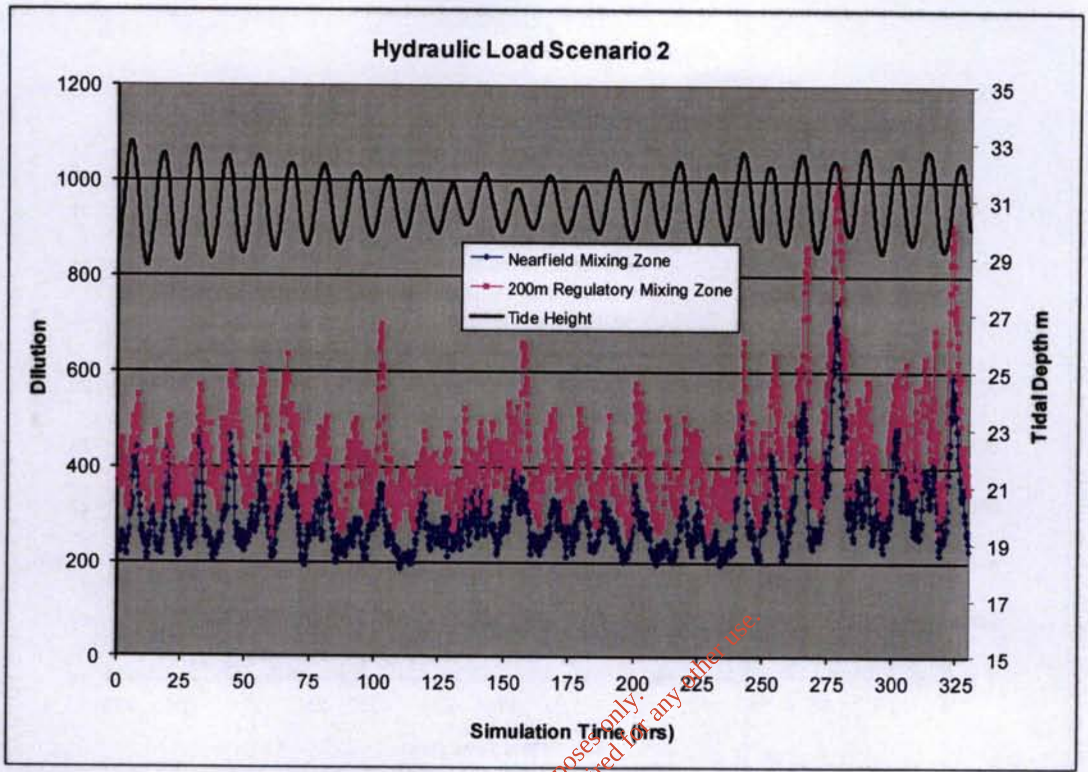

Figure 4.3 Computed Dilutions for Hydraulic Load Scenario 2 (0.283m3/s) 14day spring-neap tides

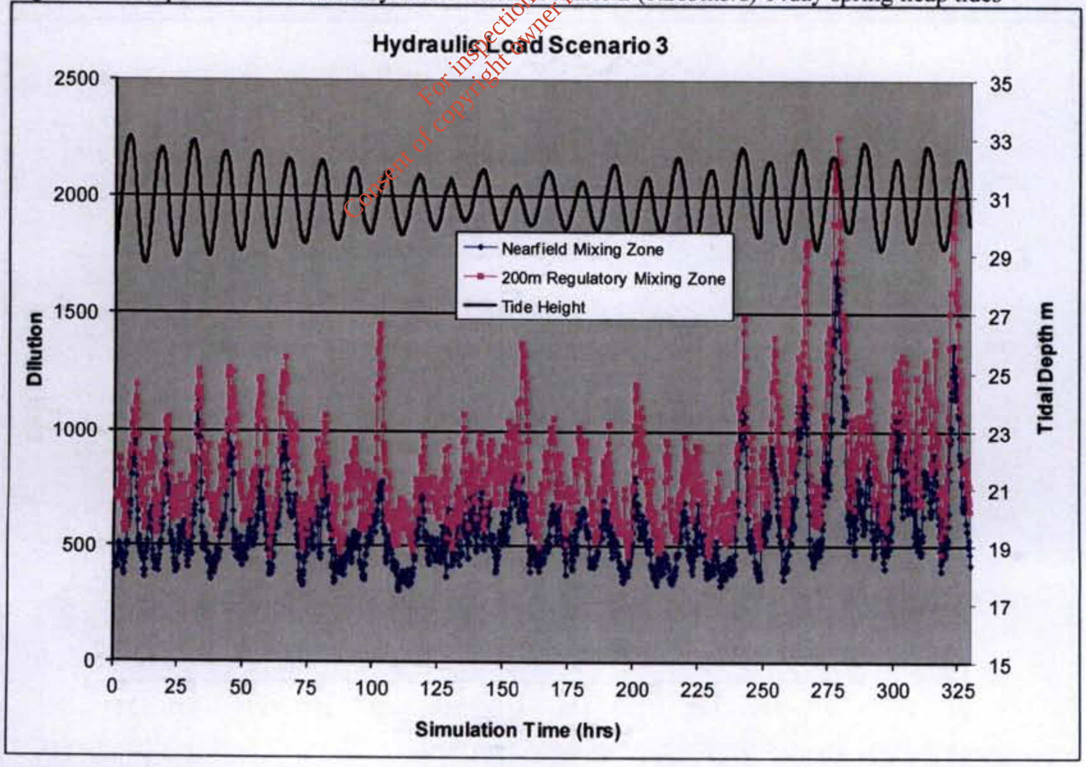

Figure 4.4 Computed Dilutions for Hydraulic Load Scenario 3 (0.118m3/s) 14day spring-neap tides

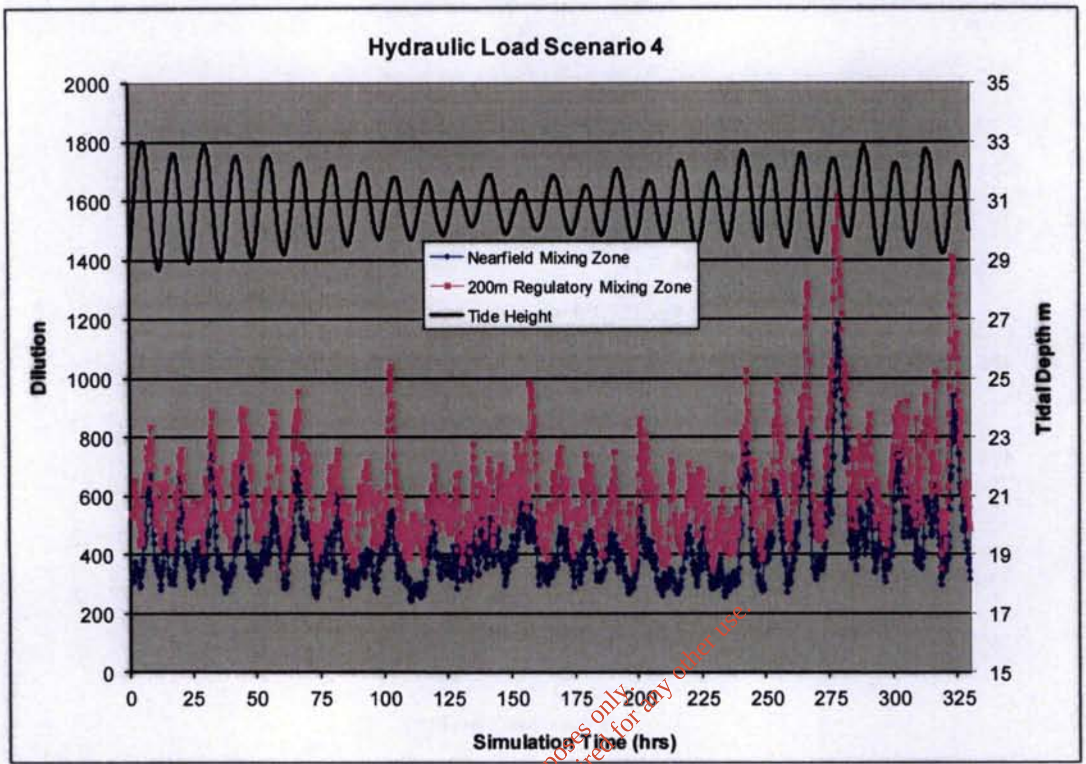

Figure 4.5 Computed Dilutions for Hydraulic Load Scenario 4 (0.173m3/s) 14day spring-neap tides

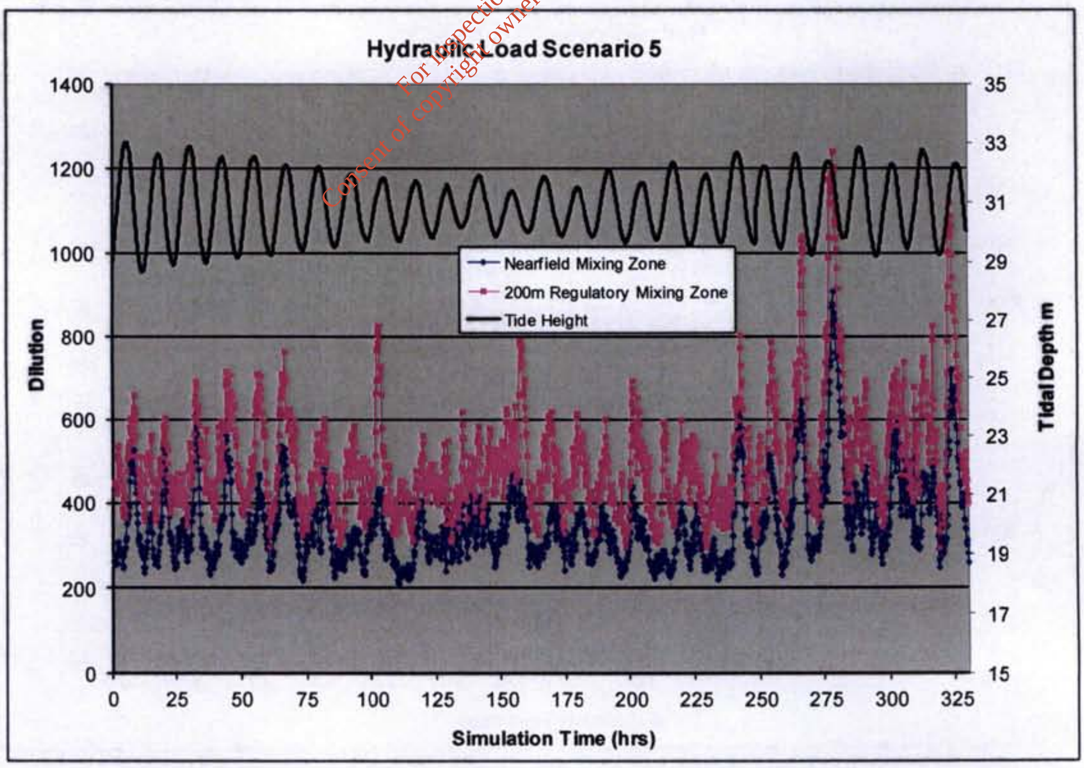

Figure 4.6 Computed Dilutions for Hydraulic Load Scenario 5 (0.228m3/s) 14day spring-neap tides

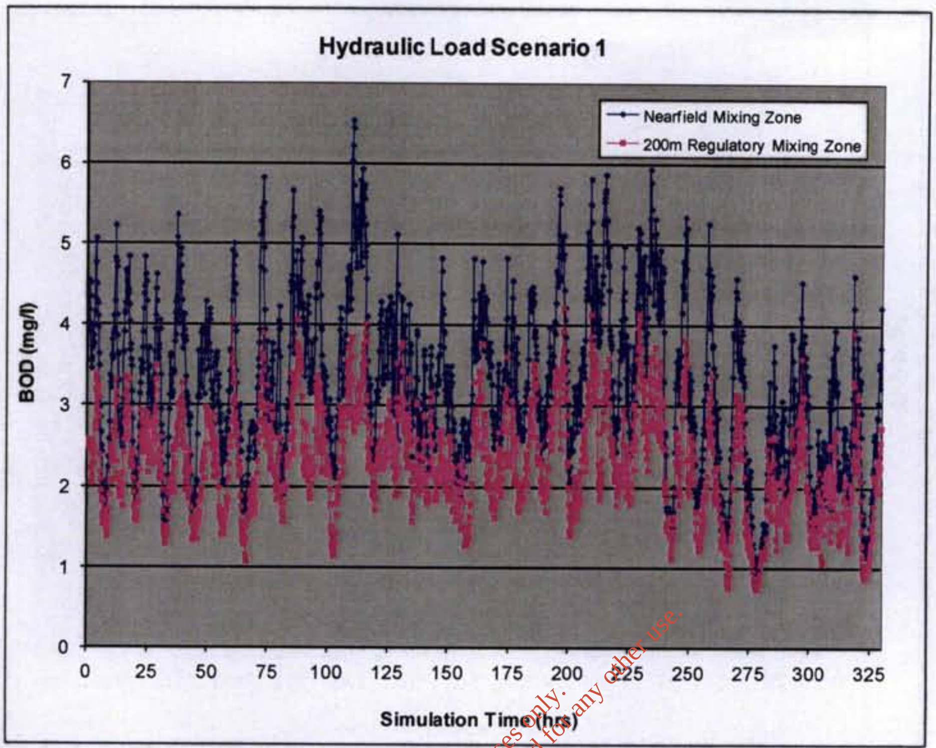

Figure 4.7 Computed BOD concentrations for Hydraulic Load Scenario 1 (0.063m3/s)

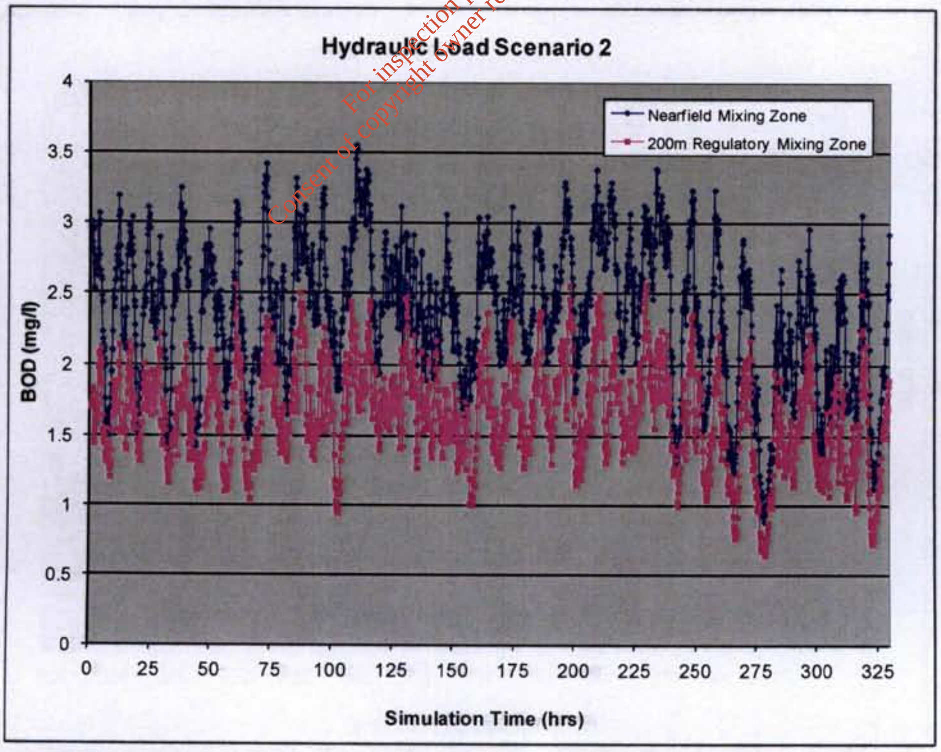

Figure 4.8 Computed BOD concentrations for Hydraulic Load Scenario 2 (0.283m3/s)

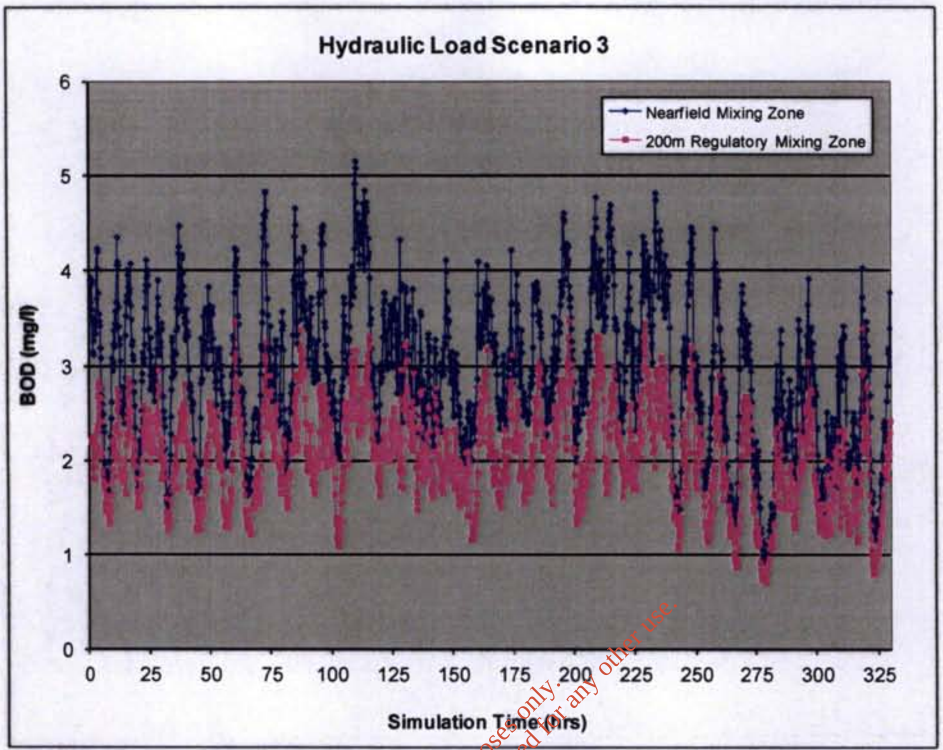

Figure 4.9 Computed BOD Concentration for Hydraulic Load Scenario 3 (0.118m3/s)

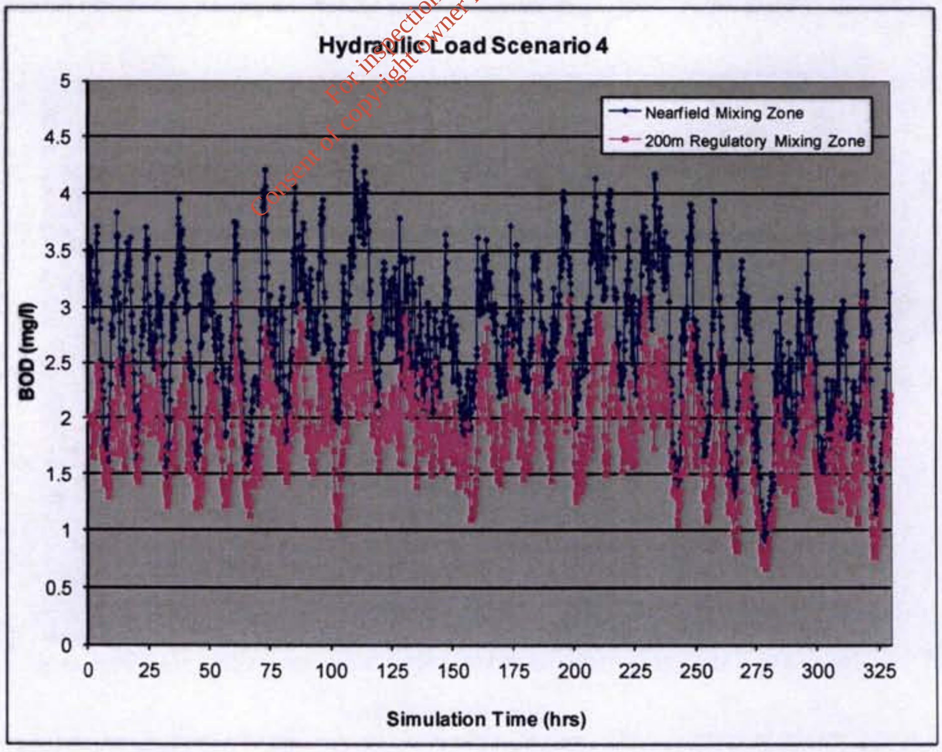

Figure 4.10 Computed BOD Concentration for Hydraulic Load Scenario 4 (0.173m3/s)

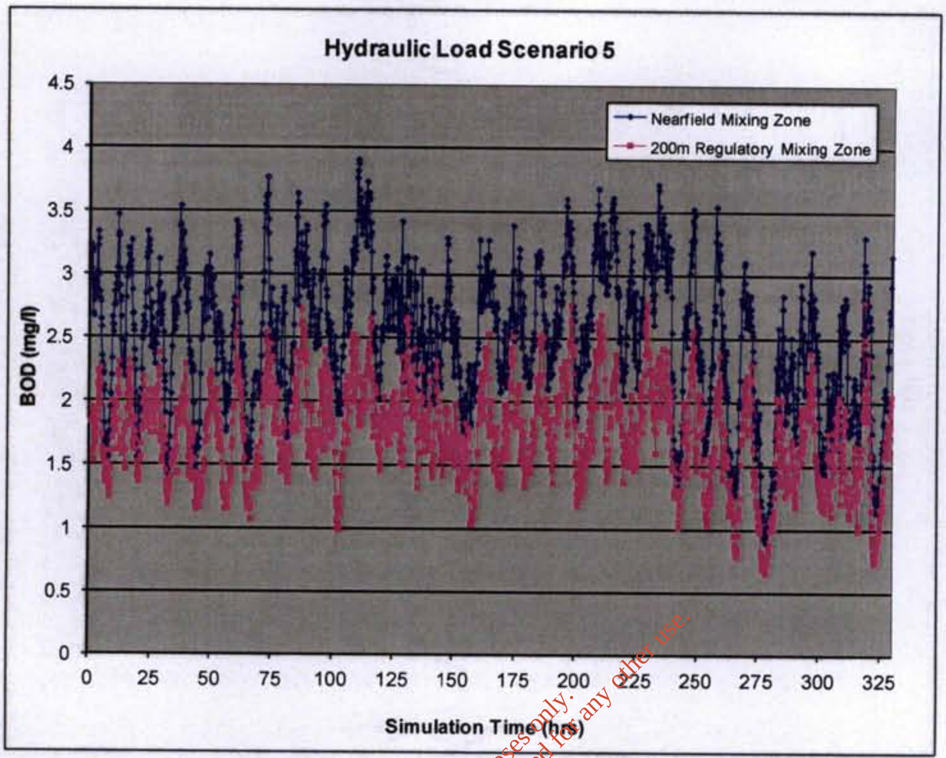

Figure 4.11 Computed BOD Concentration for Hydraulic Load Scenario 5 (0.228m3/s)

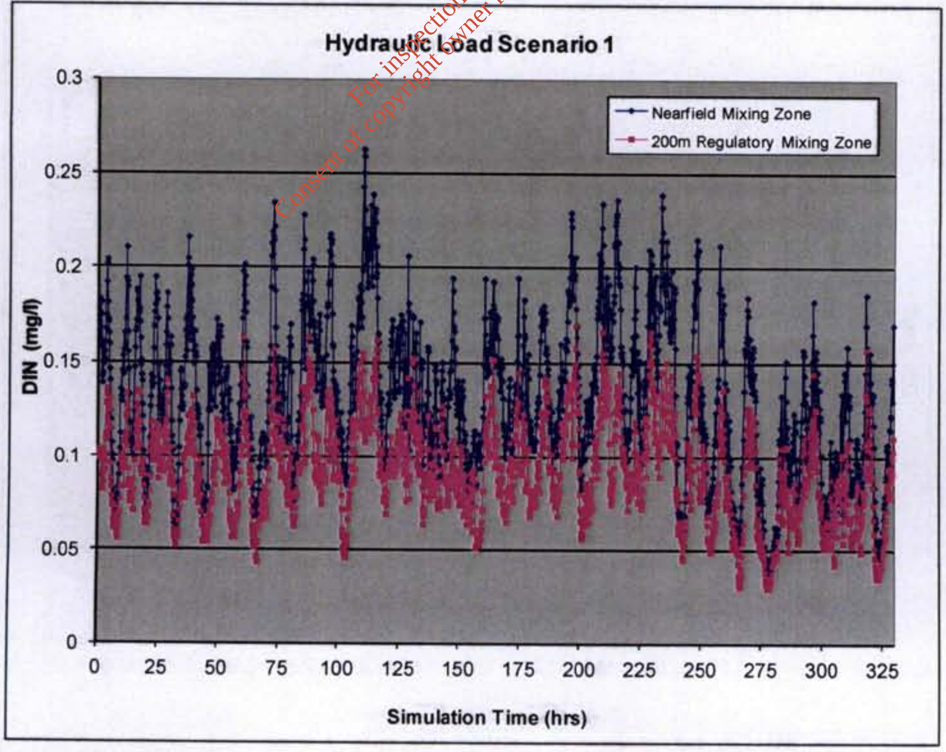

Figure 4.12 Computed DIN concentrations for Hydraulic Load Scenario 1 (0.063m3/s)

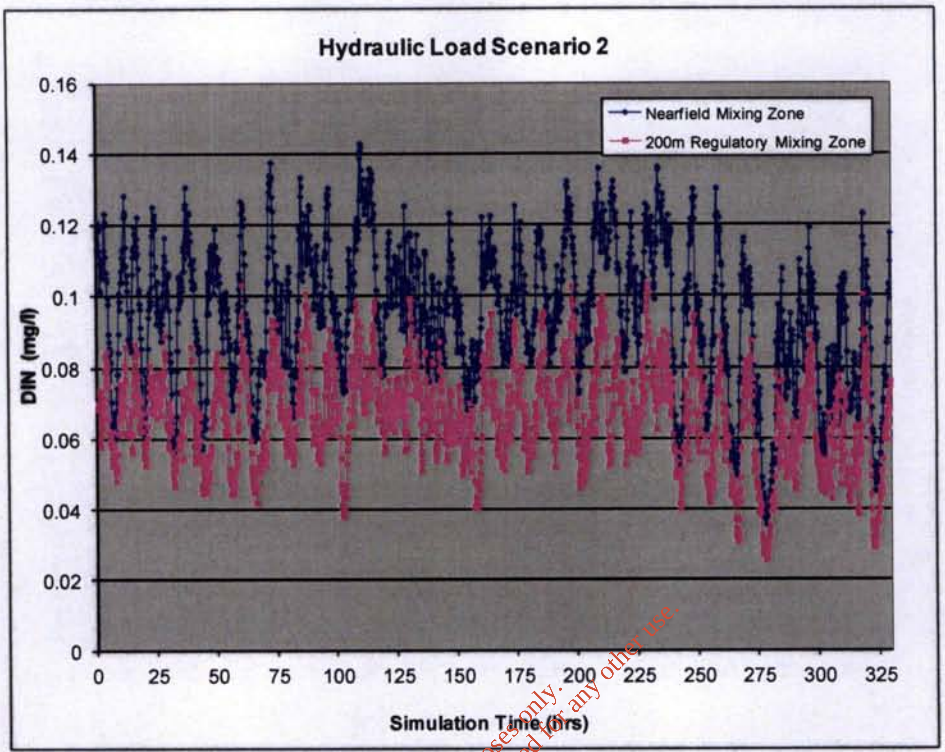

Figure 4.13 Computed DIN concentrations for Hydraulic Load Scenario 2 (0.283m3/s)

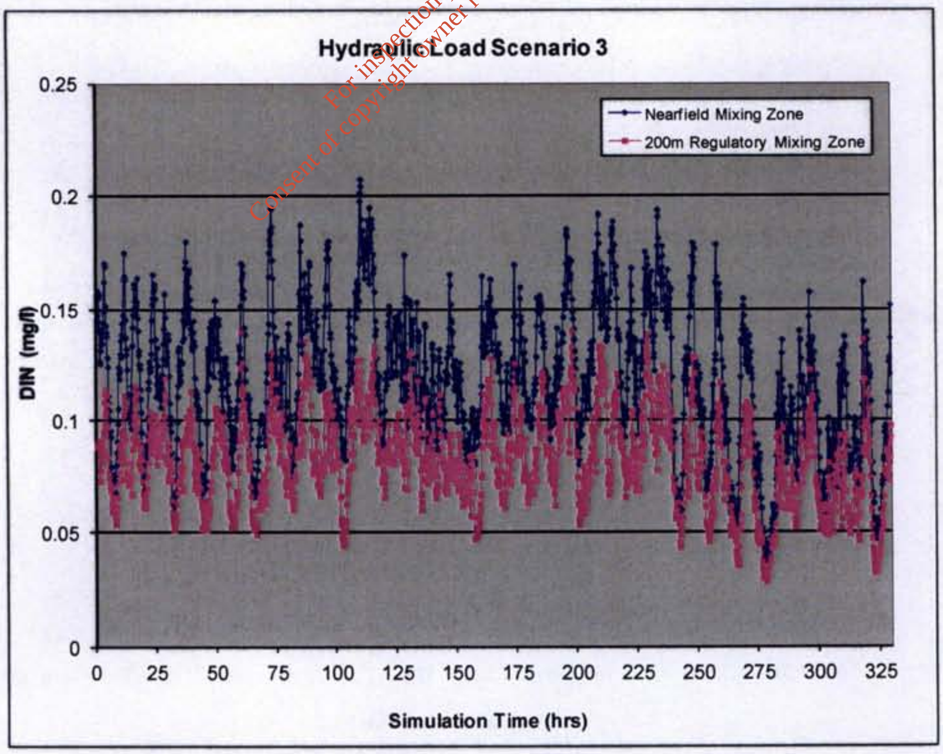

Figure 4.14 Computed DIN Concentration for Hydraulic Load Scenario 3 (0.118m3/s)

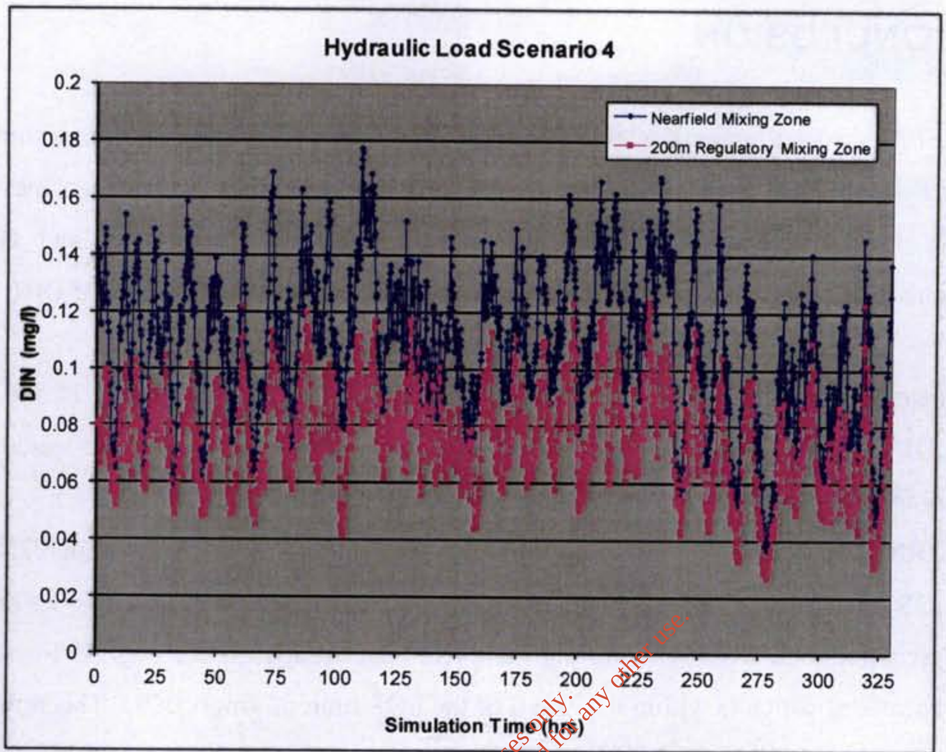

Figure 4.15 Computed DIN Concentration for Hydraulic Load Scenario 4 (0.173m3/s)

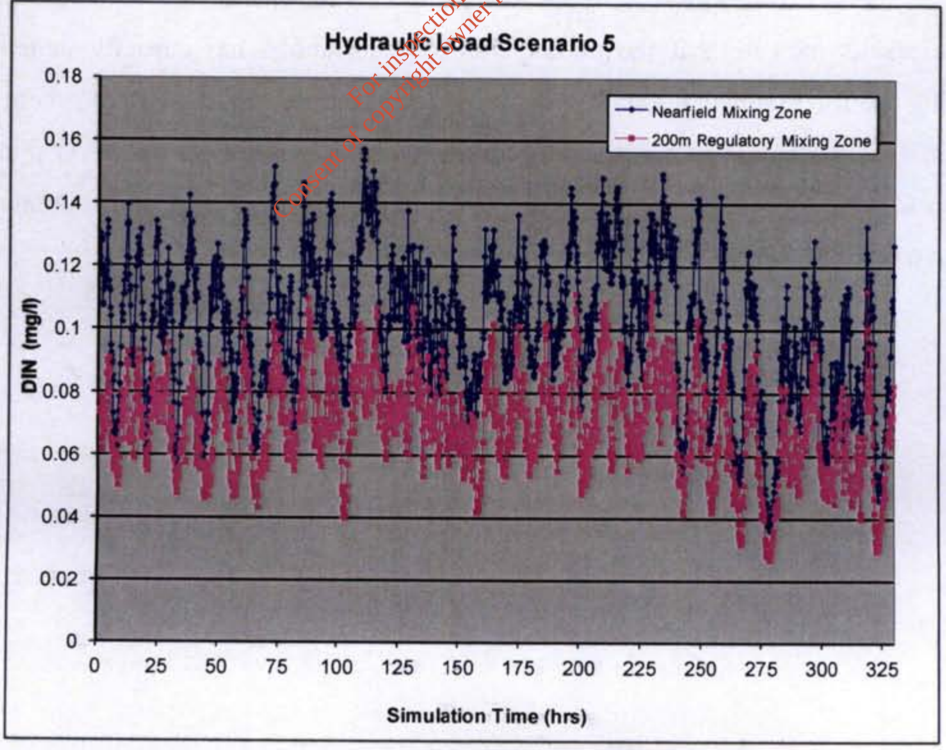

Figure 4.16 Computed DIN Concentration for Hydraulic Load Scenario 5 (0.228m3/s)

5. CONCLUSION

The EPA Visual Plumes modelling results, which exclude background concentrations show that the BAM constructed 24.0m long; 5 port marine outfall diffuser, achieves the EQS's for BOD and DIN under the range of high and low flows and effluent concentrations for the required design loads of 675kg/hr BOD and 27.15kg/hr DIN.

Estimated mean background concentrations of 1.0 mg/l BOD (AQUAFACT) and 0.165 mg/l DIN (EPA, 2009) were used. When these ambient concentrations are included the proposed effluent discharge at the 200m regulatory mixing zone will have a predicted total DIN concentration of 0.242 mg/l (median concentration) which is within 0.252 mg/l the EQS of 0.494 mg/l DIN. This represents an additional capacity of *ca.* 70 kg hr DIN. The predicted total BOD with 1.0 mg/l ambient concentration is 3.53mg/l (90-percentile concentration) which is within 0.47 mg/l of the EQS limit of 4mg/l BOD. This represents an additional capacity of *ca.* 120 kg hr BOD.

These results indicate that the outfall site at Drumbannan has capacity in terms of meeting the Environmental Quality Standards recommended by the EPA for both BOD and DIN. However, it is not advised to use up all capacity but that some level should be left so that during the on-going monitoring of the site by Donegal County Council, the output of the model can be validated over a number of seasons.

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Station No	Depth Bed	Sample Depth S	Salinity S ‰	Temp °C	DO S % Sat	TON mg/l N	NH3 mg/l N	PO4 µg/l P	DIN mg/l N	Free NH3 mg/l N	TON: NH3	DIN:PO4 µMol	DO mg/l	Season
KB220	20	0	33.17	7.42	92.2	0.12	0.03	20	0.15	0.000684	175.5	0.008	8.91	W
KB220		19	34.46	8.67	86.3	0.12	0.03	20	0.15	0.000754	159.2	0.008	8.04	W
KB240	33	0	33.53	7.49	93.6	0.12	0.03	20	0.15	0.000687	174.6	0.008	9.01	W
KB240		28.5	34.75	8.76	90.4	0.12	0.03	20	0.15	0.000759	158.1	0.008	8.39	W
KB310	33	0	33.23	7.5	91.6	0.12	0.05	20	0.17	0.001147	104.7	0.009	8.83	W
KB310		30	34.76	8.75	88.3	0.12	0.05	20	0.17	0.001264	94.95	0.009	8.20	W
KB320	31	0	33.71	7.72	92.3	0.12	0.04	20	0.16	0.000933	128.6	0.009	8.83	W
KB320		29	34.83	8.7	90.8	0.12	0.04	20	0.16	0.001007	119.2	0.009	8.43	W
KB220	18	0	32.15542	7.56	99.6	0.11	0.42	20	0.53	0.007717	0.26	58.6	9.7	W
KB220		17.7	34.03322	8.5	93.2	0.11	0.42	20	0.53	0.008306	0.27	58.6	8.7	W
KB230	32	0	31.85993	7.76	100.9	0.12	0.02	20	0.13	0.000373	5.5	14.37	9.8	W
KB230		30.5	34.13808	8.55	91.8	0.11	0.02	20	0.13	0.000397	5.5	14.37	8.6	W
KB310	34	0	31.39286	7.59	101.5	0.12	0.01	20	0.13	0.000231	12	14.37	9.9	W
KB310		30.4	34.15714	8.54	94	0.12	0.01	20	0.13	0.000249	12	14.37	8.8	W
KB320	32	0	31.47865	7.66	101.9	0.12	0.01	20	0.13	0.000232	12	14.37	9.9	W
KB320		26	34.2	8.6	96	0.1	0.01	20	0.13	0.0002	12.0	14.4	9	W
KB220	19.4	18.9	34.64	7.9	94	0.15	0.03	20	0.18	0.000566	5	19.90	8.9	W
KB220	19.4	0	31.03	7.32	103.6	0.15	0.03	20	0.18	0.000541	5	19.90	10.18	W
KB230	30	29.6	34.79	8.23	83.3	0.15	0.05	30	0.2	0.000772	3	14.7	7.8	W

Station No	Depth Bed	Sample Depth S	Salinity S ‰	Temp °C	DO S % Sat	TON mg/l N	NH3 mg/l N	PO4 µg/l P	DIN mg/l N	Free NH3 mg/l N	TON: NH3	DIN:PO4 µMol	DO mg/l	Season
KB230	30	0	30.97	7.2	103.7	0.14	0.03	20	0.17	0.000536	4.666667	18.8	10.2	W
KB310	30	0	30.84	7.18	103.7	0.15	0.03	20	0.18	0.000535	5	19.9	10.2	W
KB310	30	27.8	34.8	8.2	89.5	0.15	0.03	20	0.18	0.00058	5	19.9	8.4	W