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APPENDIX A

ICW System – Preliminary Design Calculations

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CALCULATION SHEET

Prepared By: J Merrick Date: 21.01.13

Checked By: P McShane Date: 21.01.13

PROJECT: **PROPOSED CONSTRUCTED WETLANDS SYSTEM – CONNOLLY'S REDMILLS, GORESBRIDGE, CO KILKENNY**

SUBJECT: **PRELIMINARY CALCULATIONS**

Remarks

References

1) Drawing Number IE771-002-A

2) Agroclimatic Atlas of Ireland (AGMET, Dublin, 1996)

3) Treatment Wetlands, Kadlec & Knight (CRC Press 1996)

Introduction

IE Consulting Engineers were requested by Connolly's Redmills to design a proposed integrated constructed wetland system (ICW) to intercept and treat potentially organically enriched surface water run-off from an area of their site facility at Goresbridge, Co Kilkenny.

These calculations are provided to assess the initial sizing requirements for the ICW system.

These calculations should be read in conjunction of the relevant site layout drawings

Remarks

1) *Surface Water Run-off Characterisation*

a) *Volume*

The total yard catchment area is approximately 12,300m^2, of which 4810m^2 is roof area and 7490m^2 if hardstanding yard areas.

Applying a run-off co-efficent of 0.90 for roof areas and 0.80 for yard areas, the effective catchment areas is therefore:-

(4810 x 0.9) + (7190 x 0.8) = 10,081m^2

The annual average rainfall amount from this area of Kilkenny is 823mm, which equates to a average daily rainfall amount of 2.25mm.

Therefore, the volume of surface water run-off generated from the catchment area, based on the average daily rainfall amount is therefore:-

10,081 x 2.25/1000 = **22.7 m^2**

Considering daily rainfall amounts of 5mm per day and 10mm per day the volume of surface water run-off generated from the catchment area would be **50.4m^3** and **100.8m^3** respectively

The proposed ICW system is therefore assessed in consideration of the above daily discharge volumes.

b) *Organic Content of Surface Water Run-off*

The organic content of the surface water run-off is based in consideration of the main water quality parameters of Ammonia (N) and Ortho-Phosphate (P) as well as COD. The level of organic material assumed is based on the maximum levels recorded by Kilkenny County Council in September 2011.

COD = 5410 mg/l

Ammonia (N) = 13.5 mg/l

Ortho-Phosphate (P) = 10.2 mg/l

c) *Other Factors*

The average temperature of the coldest month is 4.5 ^{0}C [(1)]

(1) *Agroclimatic Atlas of Ireland*

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Remarks

2) ICW Modelling and Design

a) Preliminary Information

The wetland system is designed as a series of ICW pond cells in series as shown on Drawing Nuymber IE711001. For this particular application 4 wetland ponds are proposed, with approximate minimum pond areas as listed below: -

ICW Pond Cell No.	*Area*
1	2125 m^2
2	2125 m^2
3	2125 m^2
4	2125 m^2

A typical wetland depth of 0.25 metres is assumed throughout the system. This depth can be increased from time to time without adversely affecting system performance.

b) Design Formulae

Most of the design approaches for constructed wetland systems use the same basic formula, which is based on the design formula for a plug flow reactor model [2]

$$A = \frac{Q}{K_{v,t}h} \, \text{Ln} \frac{(C_{in} - C^*)}{(C_{out} - C^*)}$$

Where

A	is the required surface area (m^2)
Q	is the average or design flow rate (m^3/day)
h	is the water depth
C_{in}	is the input parameter concentration mg/l
C_{out}	is the desired output concentration mg/l
C^*	is the estimated background concentration
$K_{v,t}$	is the rate constant

(2) From Kadlec and Knight 1996 and O'Sullivan 1998

Remarks

For particular climatic conditions the rate constant and background concentration need to be adjusted for temperature as follows:

Where $K_{v,t} = K_{v,20}\theta^{t-20}$

$C^* = C^*\theta^{t-20}$

c) Site specific Parameter Values

Average temperature of coldest month	4.5 ^{0}C
Annual average rainfall amount[3]	823 mm
Typical design average daily rainfall	2.25 mm/day
Average depth of constructed wetland	0.30 m

d) General Design Parameters

Using conservative values, the general design parameters [4] are given in Table 1 below :-

	Units	***COD***	***Ortho-Phosphate (P)***	***Ammonia (N)***
K_v (*volumetric rate constant*)	*Day* $^{-1}$	0.5	0.12	0.17
θ (temp. coeff for K_v)		1.06	1.00	1.04
C*20 Background conc.	*Mg/l*	3.5 + 0.053Cin	0.02	0
θ temp. coeff for C		1.00	1.00	1.00

Table 1 : General Surface Flow Wetland Design Parameters

(3) From Met Éireann Rainfall Data (Goresbridge - Kilkenny)
(4) From Kadlec and Knight 1996 and O'Sullivan 1998

Remarks

3) Predicted Performance of Wetland

The proposed constructed wetlands system will comprise a total of 4 ponds of similar areas.

The plug flow reactor model was run for ponds 1-4 in series and the reductions in COD, Ammonia *(N)* and Ortho-Phosphate (P) were calculated.

The results of the plug flow reactor model in consideration of a 10mm daily rainfall event (**100.8m³**) run are summarised in *Table 2* below: -

Pond No.	**Pond Area (m^2)**	COD_{in} (mg/l)	COD_{out} (mg/l)	$Ammonia_{in}$ (mg/l)	$Ammonia_{out}$ (mg/l)	$Ortho\text{-}P_{in}$ (mg/l)	$Ortho\text{-}P_{out}$ (mg/l)
1	***2125***	5400	***1472***	13.50	***7.20***	10.20	***5.30***
2	***2125***	1472	***403***	7.20	***4.10***	5.30	***2.10***
3	***2125***	403	***112***	4.10	***1.90***	2.10	***0.98***
4	***2125***	112	***30***	1.90	***0.96***	0.98	***0.34***
Total	***8500***		***30***		***0.96***		***0.34***

Table 2 – Predicted Performance of Proposed ICW System – 100.8m³ Daily Inflow

The results of the plug flow reactor model in consideration of a 5mm daily rainfall event (**50.4m³**) run are summarised in *Table 3* below: -

Pond No.	**Pond Area (m^2)**	COD_{in} (mg/l)	COD_{out} (mg/l)	$Ammonia_{in}$ (mg/l)	$Ammonia_{out}$ (mg/l)	$Ortho\text{-}P_{in}$ (mg/l)	$Ortho\text{-}P_{out}$ (mg/l)
1	***2125***	5400	***632***	13.50	***4.10***	10.20	***2.01***
2	***2125***	632	***79***	4.10	***1.70***	2.01	***0.97***
3	***2125***	79	***26***	1.70	***0.51***	0.97	***0.25***
4	***2125***	26	***9***	0.51	***0.24***	0.25	***0.08***
Total	***8500***		***9***		***0.24***		***0.08***

Table 3 – Predicted Performance of Proposed ICW System – 50.4m³ Daily Inflow

a) Residence Time

Considering a typical operational water depth of 0.30m, the total volume on average stored in the constructed wetlands system is approximately 423 m³.

The average residence time for a 31.2 m³/day flow will be approximately 14 days.

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APPENDIX D

ICW – Operation & Maintenance Procedures

1 Management and Maintenance of Wetland System

1.1 General

A correctly designed, constructed and planted integrated constructed wetland system (ICW) will require effective management and maintenance if long term viability and performance of the system is to be achieved on a consistent basis.

In general constructed wetland systems do not require constant attention, however periodic ongoing analysis of wastewater and effluent are require to ensure the system is operating as designed, as well as good management and house-keeping procedures. As a minimum, visual assessment of the system should be undertaken on a weekly basis, to identify any problems at an early stage.

A properly designed, constructed and maintained ICW system should have a life expectancy in excess of 20 years.

1.2 Water Level Control

Water level control is an important component of overall constructed wetlands management. Poor water level control can inhibit the performance of a constructed wetland system by allowing over saturation, high water levels, short-circuiting of influent and unintentional drying out of the plant support medium layer. Pest and weed control can also be affected by differing water levels. Water level control in the wetland system is achieved by raising or lowering the discharge pipe. Outlet control for this particular wetland system will be provided by manually adjustable long radius bends provided at each outlet pipe.

Water level control will be dependent on the particular climatic conditions and the volume of flow through the wetland system. During the summer months or periods of drought the wetland system will be affected by evapotranspiration which may decrease the depth of water in each pond, thereby requiring the outlets to be raised to prevent the ponds from drying out. During the winter months ice formation in the ponds can decrease the retention time, in which case the outlets may also have to be raised to increase the water depth to minimise the effect of ice formation.

In times of extreme rainfall events or floods temporary storage can be provided within the wetlands system by raising the outlets. However, care should be taken to ensure that the plants do not become overwhelmed by high water levels over a long period of time. The typical operational water depth of the wetland system will be 300 – 350mm, however water depths of 500-550mmmm for periods of up to 10-12 days will normally not have any adverse impact on the wetland plants.

1 or 2 persons be responsible for water level control in the wetlands system. A procedure will be implemented whereas the water levels are visually monitored on a weekly basis during normal flow conditions and on a daily basis during periods of drought or extreme flow conditions.

1.3 Weed Control

Weeds can be used as indicators of system performance and to predict maintenance requirements. Consideration will be given in the wetland management programme as to the extent of weed control and whether weeds should or should not be allowed to proliferate. It should be noted that weeds are not necessarily detrimental to the overall wetland treatment processes, however weeds are not normally regarded as an important component of the treatment process.

Appearance of weeds can be an indication of poor water level control, with most weeds appearing when pond water levels are low. One method of weed control is to periodically flood the wetland ponds to a depth greater that the operating depth, say 400-500mm, for short periods of time, say 3-4 days.

Chemical based weed killers should not be used to control weeds in a constructed wetlands environment as these can affect non-target aquatic plants, micro-organisms and water quality.

During plant establishment phase daily inspection will note any signs of weed growth. At this stage weed seedlings can be hand removed, however care should be taken not to extract weeds with large root mats as extraction of these can cause damage the wetland plant support medium.

Weed control inspections and procedures shall form an integral part of any management and maintenance procedures.

1.4 Other Vegetation Management Considerations

There is a tendency on occasions for emergent plants growing in a constructed wetland system to be flattened, bent or collapsed by heavy horizontal wind driven rain and strong winds, especially in exposed areas. Bent or broken reed plants sometimes die and this can lead to the development of bald patches in the wetland system. However, many types of reeds, including all of the common species normally used in constructed wetlands, tend to develop a screening zone around the periphery as a result of collapse and re-growth, which minimises storm damage to other reeds in the pond. At this particular site the earth embankments of each pond will provide a degree of shelter and protection. Inspection of the system, and in particular inspection of periphery reed plants, will be undertaken following a severe storm or rainfall event.

Wind blown seeds from some reed plant species can become established in surrounding areas, however this normally only causes a nuisance if residential areas are within close proximity to the wetland system. Wind blown seed dispersion is greatest where the reed plants are sited in exposed areas and are offered no protection from pond embankments or other vegetation screenings. At this particular site the earth embankments of each pond will offer a degree of shelter and seed dispersion should be minimised.

1.5 Odour Control

Odour control in a constructed wetlands system is only normally of concern when treatment of raw domestic sewage is undertaken and where no dilution of the effluent is undertaken. Odour is much less of an issue when dealing with surface water run-off.

One of the benefits of growing vegetation in a constructed wetland system is that the plants and associated litter layer provide a natural biofilter, with the reed plants developing a population of de-odorising micro-organisms which will assist in limiting odours from the system.

Retention of effluent for short periods of time in a primary collection or storage tank can also minimise any odour.

1.6 Pest Control

The range of pests which can affect constructed wetland systems include birds, flies, mosquitoes, rats and rabbits, however a well managed constructed wetland system should not experience any significant pest control issues. Pest control can be an issue when wetland systems are employed as primary and secondary wastewater treatment systems, however the proposed system at Faha shall be employed on a tertiary treatment basis only.

Stagnant areas in a wetland system can promote fly and mosquito breeding zones and these can be controlled by temporarily flooding the particular stagnant area.

Burrowing animals can cause damage to earth embankments, particularly before a vegetation growth is established on the embankments. If burrowing damage becomes a problem then installation of close mesh fencing maybe required, or aggressive hunting, trapping or poisoning in accordance with appropriate guidelines may be necessary

2 Construction Stage Monitoring & Management

It is critical during the construction stage of the development that construction run-off, which may have elevated levels of suspended solids and other pollutants, does not discharge to the Integrated Constructed Wetlands (ICW) system and pond areas during the establishment period.

In this instance it is proposed to implement the recommendations of *CIRIA document C532 – Control of Water Pollution from Construction Sites*. This document deals with various measures and methods which can be implemented to control pollution from construction water run-off. Particular control measures and methods will depend on actual construction phases, procedures and methods to be employed and shall be designed at the pre-construction stage.

Inspection of the ICW system and pond areas area shall generally be in accordance with the recommendations given in *CIRIA document C609 – Sustainable Drainage Systems*, and, as listed in CIRIA C609 will generally include the following:-

1. *Inspection of excavations for ICW and pond areas*
2. *Inspection during the laying of incoming pipework and any interconnecting pipework within the overall system*
3. *Inspection and testing of earthworks material and any filter material to ensure adequate permeability levels are achieved*
4. *Inspection of ICW areas to ensure correct preparation prior to planting*
5. *Inspection of completed planting to ensure compliance with planting specification*

3 Operation Stage Monitoring & Assessment

Operational stage management and maintenance shall generally be implemented in accordance with *CIRIA document C609 – Sustainable Drainage Systems* and will encompass the following procedures duplicated from *CIRIA C609*:-

On-going Inspection

Routine inspection of the system shall be undertaken twice weekly for the first 2 months of operation, then weekly thereafter. Inspections shall be undertaken by site managers and/or persons responsible for landscape maintenance. The advantage of using these personnel is that they will have intimate knowledge of the development and visit the site on a frequent basis. This recurring attendance ensures monitoring of the overall wastewater treatment system and a rapid response to any problems that may be identified. A log shall be kept of all inspections and shall include the following:-

- *Name of person undertaking inspection*
- *Time and date of inspection*
- *Weather conditions*
- *Details of areas within the attenuation system being inspected*
- *Brief description of general conditions of ICW and pond areas*
- *Details of any problems encountered and action taken*

Owner's Manual

Prior to full commissioning of the system a detailed owner's manual for the system shall be developed, which shall include the following:-

- *Appropriate mapping showing the location of all elements of the wastewater treatment system within the overall development site*
- *Detailed as-built drawings showing specific details of the ICW system, incoming pipework, outgoing pipework and pond areas.*
- *A summary of how the ICW and pond areas work, their purpose and how they can be damaged*
- *Maintenance requirements (a maintenance plan) and a maintenance record*
- *Explanation of the consequences of not carrying out the maintenance that is specified*
- *Identification of areas where certain activities are prohibited (for example spraying of weed-killer in and around the vegetation of the ICW system)*
- *An action plan for dealing with accidental spillages or extreme pollution events*
- *Advice on what to do if alterations are to be made to the development and/or its associated drainage system or if service or utility companies undertake excavations or other similar works that could affect the overall wastewater treatment system.*
- *Advice for on-going performance monitoring of the overall system*

The owner's manual shall also include brief details of the design concept for the wastewater treatment system and how the owner or operator should ensure that any works undertaken within the development do not compromise this.

Routine Monitoring & Operation

Routine maintenance requirements for the ICW system and pond system shall be included in the owner's manual. A summary of maintenance requirements as duplicated from CIRIA C609 is listed below:-

Operation	*Frequency*
Inspections to identify any areas not operating correctly, eroded areas, blocked inlets or outlets	Weekly
Collect and remove from site area and area around ICW system rubbish that may be detrimental to the operation of the system, including paper, packaging, bottles and cans	Monthly
Maintain grass height on side slope of ICW and pond areas within the specified range. Ensure that soil and grass does not become compacted. Do not cut during periods of drought or when ground conditions or grass are wet, without prior agreement.	Monthly or as required
Pond bank clearance to remove bank vegetation by cutting to ground level, using an approved technique and as directed on site, up to 25% of all vegetation from the waters edge to a minimum of 1m above water level. The work shall be undertaken between September and November in any one year. This is necessary to stimulate vegetation growth at ground level, to protect banks from erosion and to provide cover for wildlife and maintain amenity	Annually or every three years
Hand-cut approximately 25% of ICW submerged and emergent aquatic plants at least 100mm above ICW base, removing all arisings to a composting facility or approved tip	Annually or every three years
Remove sediment from the first pond of the ICW system when 25% full, followed by re-planting or any wetland plants in areas disturbed by sediment removal procedures	5-7 year period

4 ICW System Performance Monitoring

In order to assess the on-going performance of the ICW system it is proposed to undertaken routine sampling and laboratory analysis of waters at selected locations within the ICW system. It is proposed that sampling and analysis shall only be undertaken during the period of the grain harvest campaign.

The proposed sampling and analysis regime is summarised in *Table 1* below:-

Sample Point	*Sample Method*	*Analysis Parameter*	*Sampling Frequency*
Inlet to ICW Pond 1	Grab	BOD (mg/l)	Monthly
	Grab	COD (mg/l)	Bi-weekly
	Grab	Ammonia-N (mg/l)	Bi-weekly
	Grab	Ortho-Phosphate-P (mg/l)	Bi-weekly
Outlet From ICW Pond 4	Grab	BOD (mg/l)	Monthly
	Grab	COD (mg/l)	Bi-weekly
	Grab	Ammonia-N (mg/l)	Bi-weekly
	Grab	Ortho-Phosphate-P (mg/l)	Bi-weekly

Table 1

APPENDIX E

ICW – Assimilative Capacity Assessment

RED MILLS

WILLIAM CONNOLLY & SONS

REDMILLS,

GORESBRIDGE, CO KILKENNY

PROPOSED INTEGRATED CONSTRUCTED WETLAND (ICW) SYSTEM

ASSIMILATIVE CAPACITY ASSESSMENT

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WILLIAM CONNOLLY & SONS

REDMILLS,

GORESBRIDGE, CO KILKENNY

PROPOSED INTEGRATED CONSTRUCTED WETLAND (ICW) SYSTEM

ASSIMILATIVE CAPACITY ASSESSMENT

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Carlow

Client :-
William Connolly & Sons
Redmills,
Gorebridge,
Co. Kilkenny.

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Table of Contents

1. INTRODUCTION

IE Consulting was retained by William Connolly & Sons Ltd. to undertake an assimilative capacity assessment in respect of a proposed Integrated Constructed Wetland (ICW) system to be constructed on lands opposite the Connolly's Redmills facility, Goresbridge Co Kilkenny.

The proposed ICW system shall intercept and treat surface water runoff from a hardstanding area within the Redmills facility. The ICW system shall comprise a series of constructed ponds interconnected with pipework and planted with emergent plant spices. Surface water run-off from hardstanding areas shall discharge to the first pond of the ICW system and flow via gravity through the remaining ponds. Final discharge from the last pond of the ICW system shall be to an adjacent drainage ditch, which in turn discharges to the River Barrow approximately 140m downstream.

This assimilative capacity assessment is therefore based on consideration that the River Barrow is the primary receiving watercourse and considers the impact that the discharge from the ICW system may or may not have on the River Barrow.

2. DESCRIPTION OF RECEIVING WATER COURSE

In the context of this particular assimilative capacity assessment the River Barrow is the 'receiving watercourse'. The River Barrow is located to the east of the proposed ICW site and flows in a southerly direction along the site boundary.

3. ASSESSMENT OF FLOW CONDITIONS IN RECEIVING WATERCOURSE

The 95%ile flow condition in the River Barrow the point of discharge were sourced from the EPA's online *Hydrometrical Data System*, the full report can be found in *Appendix A*. The catchment area of the receiving watercourse upstream of the discharge location estimated at approximately 2523.5 km^2, and predominately comprises agricultural lands with smaller areas of urban development.

4. BACKGROUND PHYSICO-CHEMICAL QUALITY OF RECEIVING WATERCOURSE

The current status or classification of the receiving watercourse is 'Good' under the Water Framework Directive (WFD). As part of an on-going surface water monitoring program undertaken by Connolly's Redmills water samples from the River Barrow are obtained and laboratory on a regular basis from a point approximately 30m upstream of the proposed ICW system. *Table 1* illustrates the levels of COD, Ammonia and Orthophosphate analysed at this upstream location at various dates between 2010 and 2012.

Date	COD (mg/l O^2)	Ammonia (mg/l)	Ortho-P (mg/l)
31-08-2010	11	0.01	-
24-02-2011	13	0.05	0.03
15-06-2011	17	0.01	0.05
20-10-2012	19	0.06	-
25-01-2012	19	0.01	0.05
17-05-2012	25	0.01	0.05
Total	104	0.15	0.18
Average Value	17.33	0.03	0.05

Table 1: Hydro-chemical Results for Barrow River at "Upstream Barrow" (Upstream of discharge location)

5. CHARACTERISTICS OF DISCHARGE FROM ICW SYSTEM

5.1 *Discharge Volume*

The maximum volume of discharge from the proposed ICW system is $100.8m^3$/day, or $0.0012m^3$/s *(see ICW planning report for details of ICW discharge volumes)*.

5.2 *Discharge Quality*

The proposed ICW system has been designed to achieve the following effluent discharge quality, based on a maximum daily discharge volume of $100.8m^3$/day :-

COD – 30 mg/l

Total Ammonia (N) – 0.96 mg/l

*Ortho-Phosphate (P) – 0.34 mg/l **

*(*Note: Ortho-Phosphate is assumed as Molybdate Reactive Phosphorus)*

6. ASSIMILATIVE CAPACITY CALCULATIONS

The assimilative capacity assessment outlines the water quality for the parameters of COD, Total Ammonia and Ortho-Phosphate. It uses the 95%ile flow of the receiving watercourse (River Barrow) of **$5.758m^3$/s**, the upstream background water quality information as illustrated in *Table 1* above and the discharge volume and average discharge quality from the proposed ICW system as listed in *Section 5* above.

The Assimilation Capacity (WAC) at daily average discharge flow is calculated as follows:

$$C_{ds} = \frac{((Q_u \times C_u) + (Q_d \times C_d))}{Q_u + Q_d}$$

Where:

Q_u = the receiving watercourse flow upstream of the discharge (5.758m^3/s)

C_u = the background concentration of pollutants in the receiving watercourse upstream of the discharge

Q_d = the discharge flow from the proposed ICW system (0.0012m^3/s)

C_d = concentration of pollutants in the discharge from the ICW system

C_{ds} = the resultant concentration of pollutant in the receiving watercourse

(See *Appendix B* for assimilative capacity calculations).

A summary of the results from the assimilative capacity calculations are illustrated be seen in *Table 2* below:-

Date	COD (mg/l)	Ammonia (mg/l)	Ortho-P (mg/l)
Background Water Quality in Receiving Watercourse (upstream of discharge)	17.33	0.03	0.05
Average Discharge Quality from ICW System	30	0.96	0.34
Predicted concentration after Discharge	17.33	0.030	0.050
Increase from Background Concentration	0.01%	0.63%	0.12%

Table 2: Predicted Water Quality in Receiving Watercourse

7. SUMMARY AND CONCLUSION

An assimilative capacity assessment has been undertaken for the River Barrow, which will be the receiving watercourse for discharge from the proposed ICW system.

Using the EPA's *Hydrometric Data System*, the 95%ile flow of the receiving watercourse was determined along the reach adjacent to the proposed discharge location. Background quality of the receiving watercourse was based on water quality analysis undertaken by Connolly's Redmills between 2010 and 2012.

In summary, the assimilative capacity assessment indicates that discharge from the final pond of the proposed ICW system will not have an adverse impact on the water quality in the River Barrow.

8. REFERENCES

- European Communities Environmental Objectives (Surface Waters) Regulations 2009. S.I. No. 272 of 2009.
- Environmental Protection Agency (EPA) Hydrometric Data System

APPENDIX A

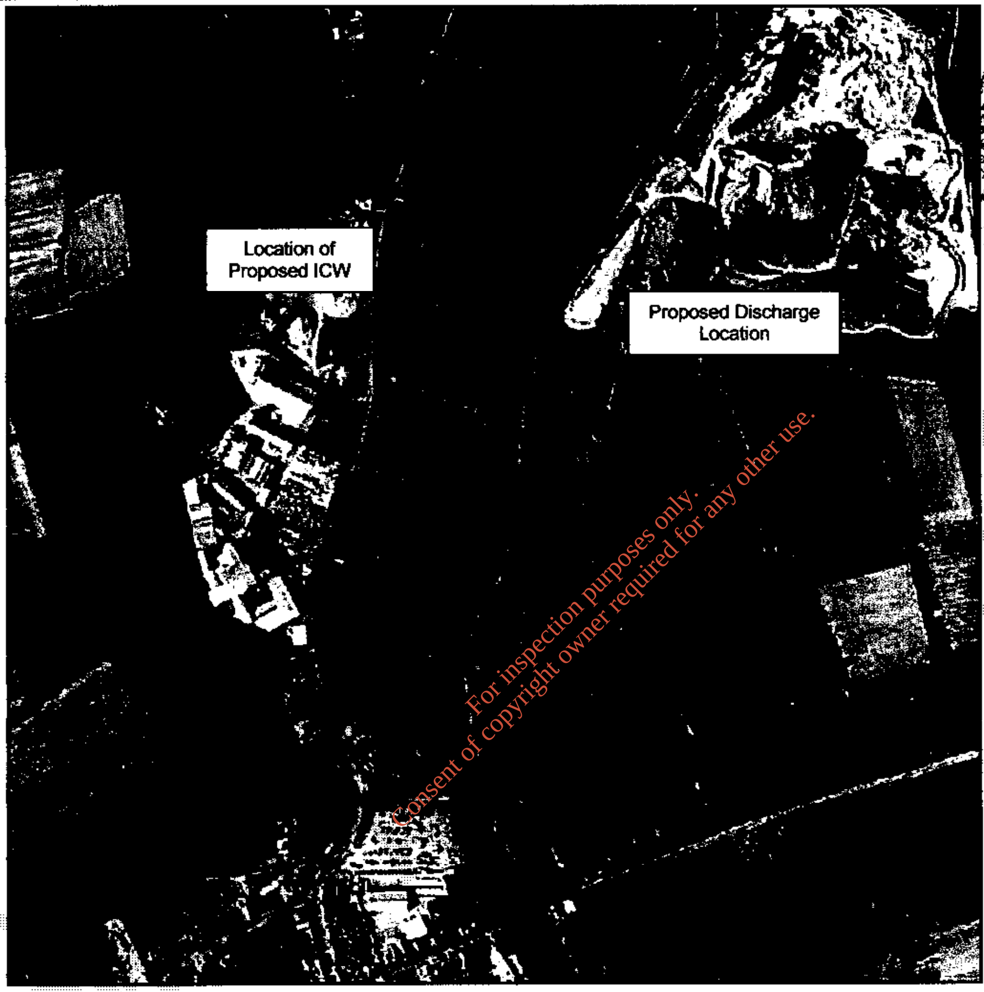
Estimation of 95%ile Flow in River Barrow (14_217)

epa Environmental Protection Agency

Estimation of Flow Duration Curve for Unga[...]

	Barrow(14_217)
	268425,154438 (ING)

River Segment Map



Disclaimer
The source hydrometric data used to estimate the flow duration curve ordinates for ungauged catchments was obtained from (1) water level data and (2) the rating curve(s) generated for each hydrometric station. The Environmental Protection Agency and the Office of Public Works used these data, respectively, to calculate daily mean flows. The daily mean flows were then used by the Environmental Protection Agency to prepare flow duration curves for each station. Neither body accepts any liability for the subsequent handling of the data.

Disclaimer

The source of hydrometric data used to estimate the flow duration curve ordinates for ungauged catchments was obtained from (1) water level data and (2) the rating curve(s) generated for each hydrometric station. The Environmental Protection Agency and the Office of Public Works used these data, respectively, to calculate daily mean flows. The daily mean flows were then used by the Environmental Protection Agency to prepare flow duration curves for each station. Neither body accepts any liability for the subsequent handling of the data.

The user should familiarise himself/herself with the catchment being studied and confirm that the ungauged site is in a natural catchment where flows conditions are suitable for the use of the model.

It is strongly recommended that the user examine the catchment descriptors contained in the report produced and confirm that the percentages of the various constituent elements are comparable to a natural catchment.

If the flow in a catchment is not entirely natural, the estimation of flows using the model in these catchments could be affected due to:

- existence of local conduit karst within the catchment;
- the selected location itself is on local conduit karst;
- regulation of the river flow on the river channel (e.g. power station, sluice gates etc)
- impacts of abstractions upstream of the selected location or the impact of the discharge associated with the abstraction into the same/different catchment;
- estimates of flow being sought at locations effected by storage effects at, or near, lake outfalls;
- lack of similar catchments with observed flows, ie where catchment descriptors lie outside the range of available gauging station catchments (e.g. the catchment area is under 5 km²);
- any other special circumstances that may affect river flows.

Expert judgement will be required to ensure that the estimate of flow is not unduly affected by any of these influences.

Please note that the model does not provide estimates of flood peaks and, specifically, should not be used for that purpose.

The EPA has also prepared estimates of DWF and long term 95 percentile flows which are also presented on the EPA web site. These data are presented at http://www.epa.ie/whatwedo/monitoring/water/hydrometrics/data/

The data produced by the model for specific stations should be compared to the data contained in this file of DWF and long term 95percentile flows.

Disclaimer

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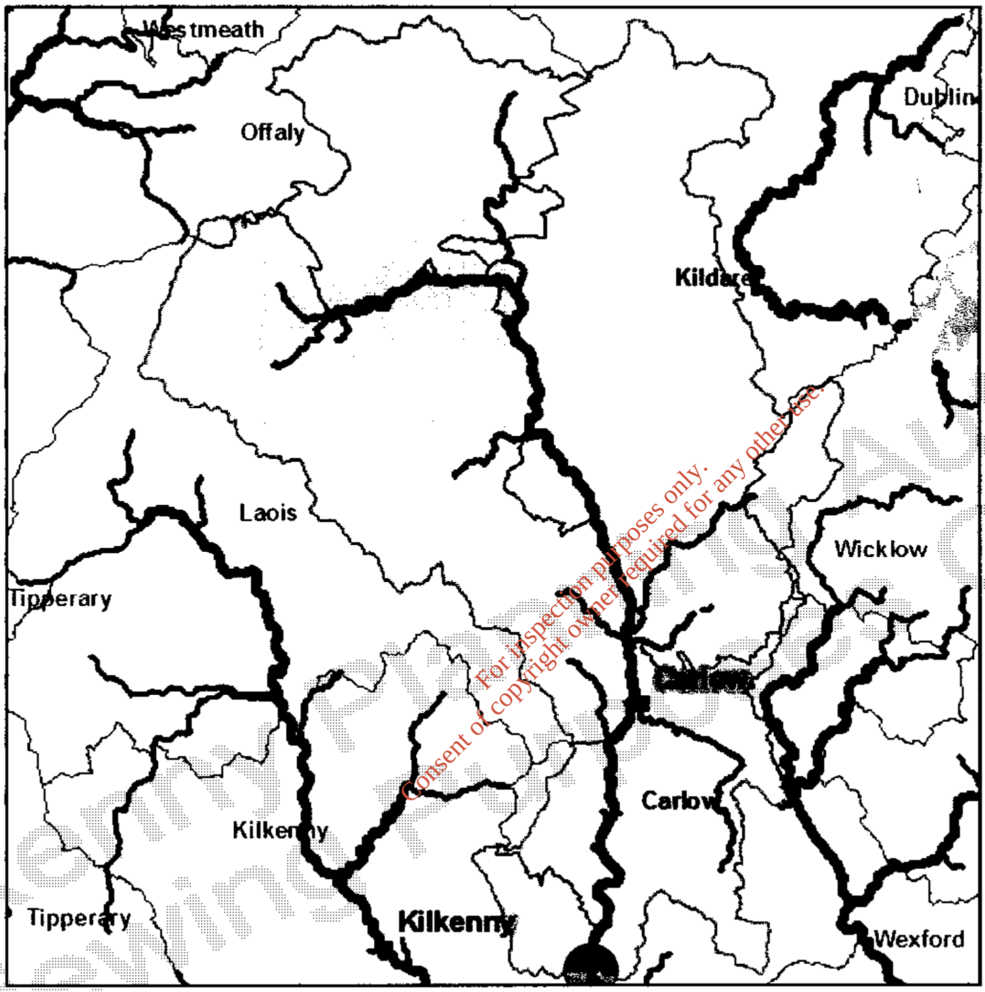
Estimation of Flow Duration Curve for Ungau...

Environmental Protection Agency

[redacted]	Barrow(14_217)
	268425,154438 (ING)

Nested Catchment Map



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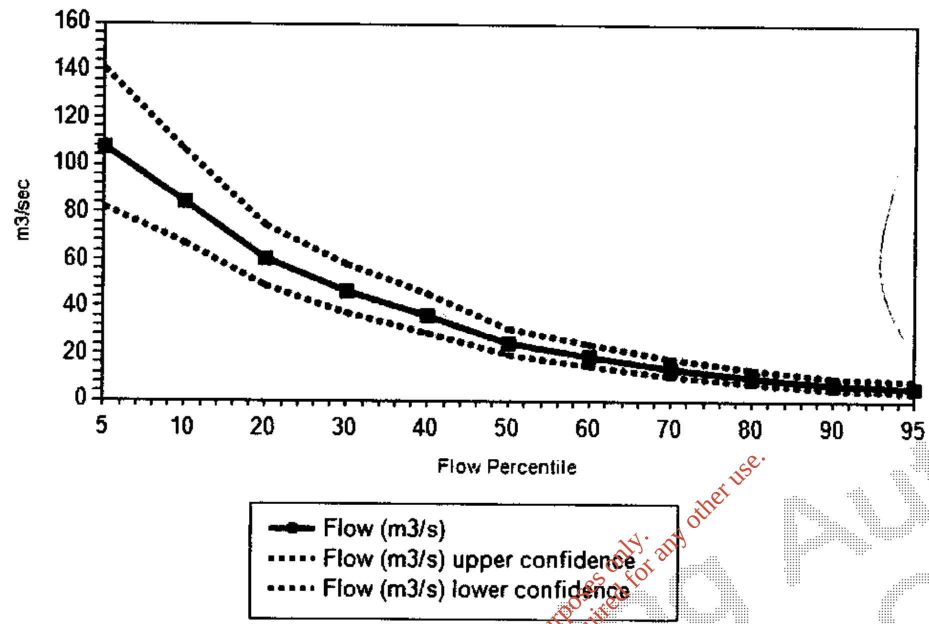
Estimation of Flow Duration Curve for Ungau

Flow Duration Curve (Flow in m3/sec)



5	107.555	140.682	82.228
10	84.444	106.4	67.019
20	60.375	74.623	48.847
30	46.54	57.989	37.352
40	36.145	45.434	28.755
50	24.47	30.661	19.529
60	18.872	24.024	14.825
70	13.754	17.977	10.523
80	10.076	13.451	7.547
90	7.037	9.936	4.984
95	5.758	8.636	3.838

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Catchment Descriptors		
General		
Descriptor	**Unit**	**Value**
Area	sq km	2523.5
Average Annual Rainfall (61-90)	mm/yr	862
Stream Length	km	1848.9
Drainage Density	Channel length (km)/catchment area (sqkm)	0.7
Slope	Percent Slope	2.8
FARL	Index (range 0:1)	1

Soil	
Code	**% of Catchment**
Poorly Drained	23.5
Well Drained	47.6
Alluvmin	5.6
Peat	22.2
Water	0
Made	1.2

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Subsoil Permeability		
Code	**Explanation**	**% of Catchment**
H	High	16.5
M	Moderate	46.8
L	Low	20.5
ML	Moderate/Low	0
NA	No Subsoil/Bare Rock	16.2

Aquifer		
Code	**Explanation**	**% of Catchment**
LG_RG	LG:Locally important sand-gravel aquifer RG: Regionally important sand-gravel aquifer	14.5
LL	Locally important aquifer which is moderately productive only in local zones	35.5
LM_RF	LM: Locally important aquifer which is generally moderately productive RF: Regionally important fissured bedrock aquifer	6.7
PU_PL	PU: Poor aquifer which is generally unproductive PL: Poor aquifer which is generally unproductive except for local zones	17.2
RKC_RK	Regionally important karstified aquifer dominated by conduit flow	0
RKD_LK	Regionally important karstified aquifer dominated by diffuse flow	25.5

Stations in Pooling group			
%ile Flow	**Station 1**	**Station 2**	**Station 3**
5	07012	15006	07009
10	07012	15006	07009
20	07012	15006	07009
30	07012	15006	07009
40	07012	15006	07009
50	07003	14019	07009
60	07003	14019	07009
70	07003	14019	07009
80	07003	14019	07009

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90	07003	14019	07009
95	07003	14019	07009

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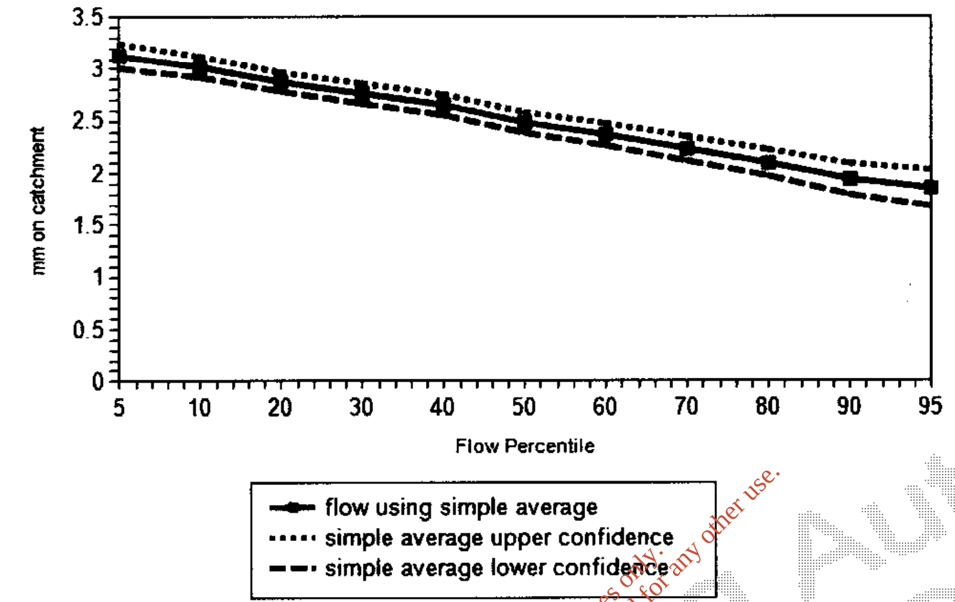
Estimation of Flow Duration Curve for Ungau...

Flow Duration Curve (mm on catchment)



5	3.129	3.246	3.012
10	3.024	3.124	2.924
20	2.878	2.97	2.786
30	2.765	2.861	2.669
40	2.656	2.755	2.557
50	2.486	2.584	2.388
60	2.373	2.478	2.268
70	2.238	2.354	2.122
80	2.102	2.228	1.976
90	1.945	2.095	1.795
95	1.858	2.034	1.682

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APPENDIX B

Assimilative Capacity Calculations

ie
IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

IE771- Connolly's Redmills

		%increase
COD		
Background stream conc	17.33	
Effluent conc	30	
Effluent flow m3/s	0.0012	
Stream avg flow m3/s	5.758	
	-	
Predicted conc. Avg flow	*17.333*	*0.01*
Ammonia		
Background stream conc	0.03	
Effluent conc	0.96	
Effluent flow m3/s	0.0012	
Stream avg flow m3/s	5.758	
	-	
Predicted conc. Avg flow	*0.030*	*0.63*
Ortho-P		
Background stream conc	0.05	
Effluent conc	0.34	
Effluent flow m3/s	0.0012	
Stream avg flow m3/s	5.758	
	-	
Predicted conc. Avg flow	*0.050*	*0.12*