Appendix A13.3 Biological Q-rating Assessment of the Morell River

Water Quality Assessment of the Morell and Hartwell Rivers adjacent to the Kerdiffstown Facility in Co. Kildare

Final Report

Prepared by Aquens Ltd.
December 2012

INTRODUCTION

AQUENS Ltd. was commissioned by Environmental Protection Agency to undertake a biological assessment of the water quality of the Morell and Hartwell River, Co. Kildare to assess the potential impact the Kerdiffstown facility may be having on the aquatic habitat. In December 2012 an assessment was undertaken at six sampling localities on the Morell River and one on the Hartwell stream to assess the upstream and downstream water quality as indicated by the benthic macroinvertebrate community. As the Hartwell River joins the Morell River adjacent to the Kerdiffstown facility the water quality of the Hartwell River and its influence in the Morell River had to be included during this assessment.

MATERIALS & METHODS

The water quality assessment was undertaken using the benthic macroinvertebrates as bioindicators. These are an excellent tool for water quality assessment as they exhibit differential responses to physical and chemical changes in their environment. Some macroinvertebrates are sensitive to pollution while others are tolerant. They provide a realistic record of the prevailing water quality conditions.

On request of the client macroinvertebrate sampling took place on 11th December 2012. Seven sites were selected on the Morell and Hartwell Rivers and positioned to indicate the upstream and downstream water quality in relation to the facility (Figure 1). As the Hartwell River joins the Morell River along the length of the river that may be affected by the facility both upstream and downstream of the confluence had to be included (Plate 1M&H). One upstream site (M1) provides an indication of the water quality entering the area, and the other sites provided the progression downstream (M2 to M6) (Figure 1). One site (H1) provides the water quality status of the Harwell River (Figure 1), the location of the tributary and feeder streams of the constructed ponds on the golf course are not as indicated on the OSI maps. The characteristics of the sites are provided in Table 1 and these have been taken into account in the interpretation of the water quality. These measurements do no provide an exhaustive account of the physical conditions of the sampling sites.

Table 1: Site characteristics at each of the seven sites assessed on the Morell and Hartwell Rivers.

Sampling Site (OSI)	Width	Depth	T°C	DO	pH	Cond.	Dominant Substrates	In-stream Vegetation	Flow Conditions
Morell River									
M1 (N918 216)	3.6	0.55	5.0	10.08	7.96	781	Gravel, Sand (Fine & Course)	*Ranunculus* spp., good marginal	Deep fast flowing run
M2 (N918 219)	3.1	0.35	6.0	9.39	8.02	695	Sand (F & C) some Gravel	None	Shallow depositing
M3 (N918 220)	3	0.30	5.8	10.20	8.06	690	Gravel, Sand and some cobble	Some *Ranunculus* spp.	Fast shallow run
M4 (N915 222)	4.3	0.25	5.7	10.73	8.48	680	Cobble, Gravel & Sand	little *Fontinalis* spp.	Glide, Run & Riffle
M5 (N914 225)	4.4	0.30	5.5	11.60	8.44	688	Cobble, Gravel & Sand	little *Fontinalis* spp.	Run & Riffle some glide
M6 (N916 227)	3.2	0.45	5.8	12.18	7.97	662	Cobble, Gravel & Sand	little *Fontinalis* spp.	Glide, Run & Riffle
Hartwell River									
H1 (N919 220)	3.0	0.32	5.0	10.18	8.28	708	Compact clay, Gravel and some Cobble & Boulders	None	Fast Riffle & Run

The sampling method adopted was that applied by the EPA in the national river monitoring programme (McGarrigle *et. al.*, 2002). Using an FBA (Freshwater Biological Association) pond net (1mm mesh), a 2-minute, multi-habitat kick-sample was taken at each site. In addition, one minute stone-washing was also undertaken. The samples were preserved in 70% IMS and processed in the laboratory. They were sorted in an illuminated tray and all the macroinvertebrates were identified to the appropriate taxonomic resolution using FBA taxonomic keys.

The macroinvertebrate data were used to derive a Q-value using the EPA methodology (McGarrigle *et al*., 2002). This Q-value system is a five point scale (Q1-Q5: with intermediate scores obtainable, e.g. Q3-4) based on the proportions of five groups of macroinvertebrates, with different pollution tolerances. Two other biotic indices (BMWP and ASPT) were calculated. The BMWP score is based on the presence of pollution-tolerant to pollution-sensitive families. Each family is assigned a score. The BMWP score is the sum of these family scores. Families that are sensitive to pollution are assigned higher scores than pollution-tolerant families. A high overall score indicates that the water quality is good. The ASPT is determined by dividing the BMWP score by the number of scoring taxa yielding a score between 1 and 10, values >6 usually indicate excellent water quality. In addition, the taxon richness and the percentage of Ephemeroptera/Plecoptera/Trichoptera (%EPT) were determined.

A range of physical (average depth and width, mesohabitat type and substrate composition) and chemical characteristics (dissolved oxygen, temperature, conductivity and pH) were determined on site using hand-held meters (Table 1).

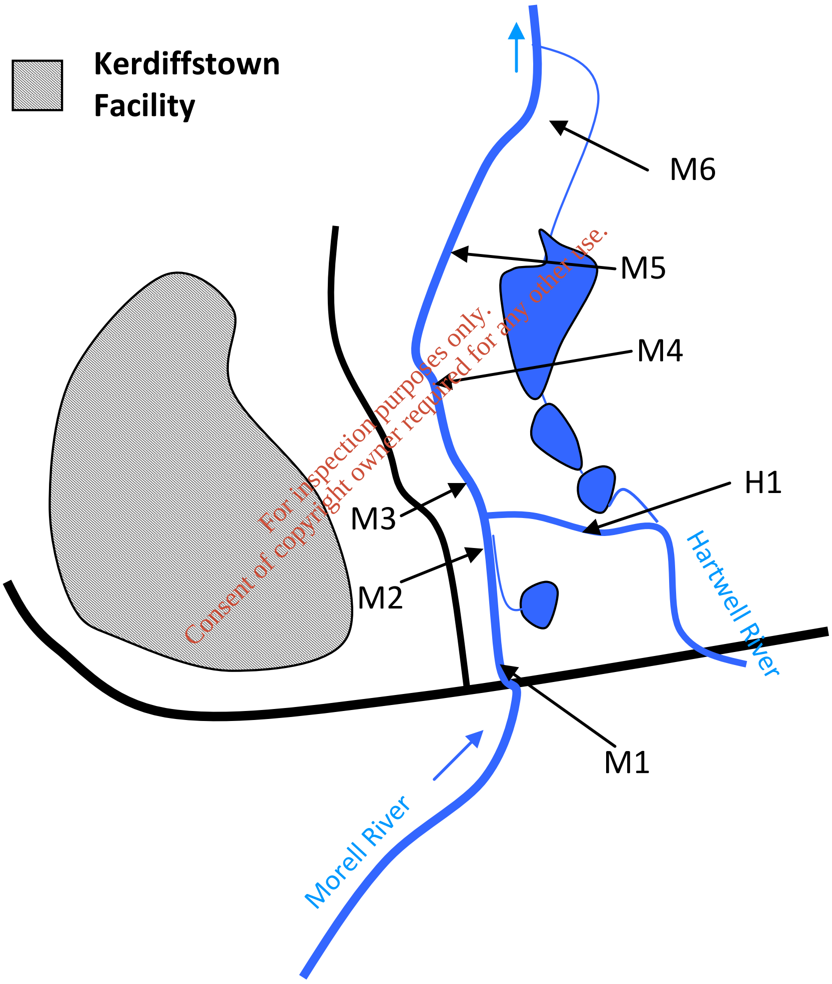


Figure 1: Schematic diagramme showing the location of sampling sites M1-6 on the Morell River and H1 on the Hartwell River in relation to the Kerdiffstown facility.

Plate 1: Sites assessed on the Morell (M) and Hartwell (H) Rivers adjacent to Kerdiffstown facility. M1 upstream, M2 upstream of two tributaries, M3 ~30m downstream of tributaries, M4, M5 & M6 further downstream, H1 50m before it joins the Morell River, M&H site where the Hartwell (left) and drainage ditch (right) joins the Morell River.

RESULTS

Site Characteristics

Sites on both rivers show that the river has been channelized in the past as the bank sides are high (1m -1.5m) throughout. The sampling sites were relatively fast flowing with little in-stream vegetation, with the exception of *Ranunculus* spp. at site M1 and M3 (Table 1). Most of the substrates were clean and sites appeared scoured. The water chemistry is indicative of the soil and geology in the area with high pH and conductivities (Table 1). Oxygen levels were within normal ranges (9.39 & 12.08 mg/l).

Benthic Invertebrates

A total of 43 taxa were recorded during the survey, with individual sites recording between 19 and 29 taxa in the single, 2-minute kick sample taken at each site (Table 2). Overall the list of species was well represented by the more sensitive groups, including Ephemeroptera, Plecoptera and Trichoptera making up almost half of the taxon richness. The cased caddis were not well represented, probably as a result of the fast flow, lack of in-stream and marginal vegetation and lack of sheltered habitats.

Water Quality

Several metrics were applied to the benthic invertebrates collected at each site. The Q-values were assigned on the basis of the sensitivity groups present in abundance, % representation and taxon richness (Table 3). It is clear that the two upstream sites (M1 & M2) have fewer Group A & B taxa present and a dominance of Group C. Although the flow was good the substrate at M2 was poor with very little suitable substrate available. With the result, few Heptigeniidae and Plecoptera were recorded. There was also no broken flow and exposed substrates at M1 presenting little habitat suitable for mayflies and stoneflies, although better substrates were present in the deeper run and glide at M1 compared to M2. The status at these two sites was assigned bearing this in mind. All the other sites had suitable habitat present and the status could be assigned with not adjustments needed to account for the lack of suitable substrates.

Table 2: Benthic invertebrate species recorded at sampling site.

Order/Group	Family	Species/genus	M1	M2	M3	M4	M5	M6	H1
Crustacea	Asellidae	*Asellus aquaticus* (L.)	94	12	9	6	4	5	7
	Gammaridae	*Gammarus duebeni* (Lilj.)	660	130	348	59	152	177	94
	Astacidae	*Austropotamobius pallipes* (L.)	1						1
Ephemeropte	Baetidae	*Baetis rhodani* (Pictet.)	213	65	396	140	568	122	360
		Alianites muticus (L.)	4		12	20	24	14	15
	Ephemerelliidae	*Seratella ignita* (Poda)	1						
	Ephemeridae	*Ephemera danica* L.			1				
	Heptageniidae	*Ecdyonurus* spp.			12		16		9
		Rhithrogena semicolorata (Curtis)	4	3	196	584	500	315	282
Plecoptera	Leuctridae	*Leuctra spp.*	2		7	9	4	7	8
	Perlodidae	*Isoperla grammatica* (Poda)	3		27	25	20	15	24
		Siphonoperla torrentium (Pictet)				2	1	1	
	Neumoridae	*Protnemura meyeri* (Pictet)		1			1		
Trichoptera	Hydropsychidae	*Hydropsyche siltalai* (Döhler)	5	4		4	8	3	3
		H. fulvipes (Curtis)	5	3	10	4	20	12	2
		Hydropsyche sp.	93	64	78	112	600	112	41
	Polcentropodida	*Plectrocnemia* spp.	2		1				
	Rhyacophilidae	*Rhyacophila dorsalis* (Curtis)	8	3	6		8	15	2
	Psychomyiidae	*Lype phaeopa* (Stephens)	16		4			9	1
		Lype reducta (Hagen)		10					1
	Limnephilidae	*Micropterna sequax* McLachlan	4						1
		Chaetopteryx villosa (Fab.)	2		3	3		3	
	Sericostomatidae	*Sericostoma personatum* (Spence in K & S)			1	1			
	Lepidostomatida	*Lepidostoma hirtum* (Fabricius)	2	2			3		
	Glossosomatidae	spp. indet.					1		
Coleoptera	Elmidae	*Elmis aenea* (Müller)	8	2	3	13	8	16	2
		Oulimnius tuberculatus (Müller)						1	
		Limnius volckmari (Panzer)	7	4	4	4	3	3	3
		Esolus parallelepipedus (Müller)	4	2	5	17	3	26	3
Mollusca	Sphaeriidae	*Sphaerium/Pisidium* spp.				2		1	
	Hyrobiidae	*Potamopyrgus antipodarum* (Gray)			1			1	
	Lymnaeidae	*Lymnaea peregra* (Müller)	5	1					
Hirudinea	Erpobdellidae	*Erpobdella octoculata* (L.)		1	1	1	1	2	4
Diptera	Chironomidae	spp. indet.	37	9	12	9	6	22	
	Simuliidae	spp. indet.	52	5	264	256	160	20	256
	Tipulidae	*Tipula* spp.	1		2	1			
	Pedicidae	*Dicranota* spp.	6	2	16	12	5	30	7
	Limonidae	*Antocha* spp.	8			1	6	67	
	Empedidae	spp. indet.	3		1		1	1	
	Muscidae	Limnophora spp.							1
	Ceratapogonidae	spp. indet.						1	
	Psychodidae	spp. indet.			1			1	1
Oligochaeta	Oligochaeta	spp. indet.	51	35	9	37	13	31	22
Arachnida	Hydracarnia	spp. indet.	1				1	6	

Table 3: The representation of each invertebrate group as separated by the Q-value system in each of the sampling sites.

Q-value Grouping	M1	M2	M3	M4	M5	M6	H1
Total Abundance							
Group A	12	4	248	631	562	345	331
Group B	10	2	11	13	8	10	9
Group C	1129	303	1152	632	1548	1649	777
Group D	150	49	19	46	18	39	33
Group E	0	1	6	2	3	4	5
Percentage							
Group A	0.9	1.1	17.3	47.7	26.3	16.9	28.8
Group B	0.8	0.6	0.8	1.0	0.4	0.5	0.8
Group C	86.8	84.6	80.6	47.8	72.5	80.7	67.6
Group D	11.5	13.7	1.3	3.5	0.8	1.9	2.9
Group E	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Number of Taxa							
Group A	4	2	5	4	6	4	5
Group B	4	1	3	3	3	2	2
Group C	18	13	17	13	14	19	15
Group D	3	4	3	4	3	4	3
Group E	0	1	6	2	3	4	5

All the sites except the two upsteam sites M1 & M2 were assigned a Q4-5, indicating that the sites had good ecological status (Table 4). The two sites M1 & M2 were assigned a Q4 which represents good ecological status but does indicate that the water quality is poorer upstream of the point at which the Hartwell enters the Morell River. The BMWP and ASPT values seem to be broadly in line with the Q values assigned (Table 4). The ASPT indicates that the community was dominated by sensitive taxa with values ranging between 5.44 and 6.32 (Table 4). The % EPT shows that most of the taxa belonged to this group, in terms of their abundances, with the lowest recorded at M1 & M2, again in keeping with the lower Q values assigned.

Table 4: Water quality scores, metric scores and invertebrate richness and abundances for 7 sampling sites.

	M1	M2	M3	M4	M5	M6	H1
Q value	Q4	Q4	Q4-5	Q4-5	Q4-5	Q4-5	Q4-5
BMWP	149	87	123	99	120	113	89
ASPT	6.21	5.44	6.15	5.82	6.32	5.65	5.93
Scoring	24	16	20	17	19	20	15
EPT Taxa (%)	28.0	43.3	52.7	68.4	83.0	79.9	65.1
Taxon Richness	29	19	27	23	26	29	24
Total Abundance	1301	358	1430	1322	2136	2043	1150

CONCLUDING COMMENTS

It is clear that both these rivers have been modified in the past, probably in order to prevent flooding and to redirect the stream to supply the ponds in the golf course. This has provided limited suitable habitat for the deposition of materials and the formation of a healthy marginal vegetation, which would provide suitable habitat for taxa that require more sheltered habitats (such as cased Trichoptera, various Coleoptera and Hemiptera). The sampling sites were all quite scoured and the invertebrate community recorded reflects this condition. However, the water quality is still quite reasonable and there are numerous sensitive taxa present in large abundances, such as *Rhithrogena* sp. and *Isoperla grammatica*. As a result of the high EPT taxa most of the sites were assigned a Q4-5, representing good ecological status. It appears that the Hartwell River is improving the water quality of the Morell River as the sites downstream of the confluence have a better ecological quality than the two upstream sites. Therefore, a pressure further upstream is probably reducing the water quality before it flows adjacent to the Kerdiffstown facility. As the water quality remains good throughout the length of the Morell River assessed during this survey, there does not seem to be deterioration in the ecological status as a result of the Kerdiffstown facility. As the assessment was completed in December the status as indicated here should be interpreted with some care particularly if direct comparisons between this and past surveys completed by the EPA (as part of their monitoring programme) are made. However, the upstream downstream comparisons are still appropriate and the trend downstream indicates that there are no discernible changes to the invertebrate community as a result of the facility. It may be advisable to conduct bank side assessments in the summer, when water levels may be lower and temperatures higher, to confirm the status and have comparable values to previous EPA surveys, which are usually completed during the summer months.

REFERENCES

McGarrigle, M.L., Bowman, J. J., Clabby, K. J., Lucey, J., Cunningham, P., MacCárthaigh, M., Keegan, M., Cantrell, B., Lehane, M., Clenaghan C. and Toner, P. F. (2002) Water Quality in Ireland 1998 – 2000. EPA.

WATER QUALITY ASSESSMENT OF THE MORELL AND HARTWELL RIVERS ADJACENT TO THE KERDIFFSTOWN FACILITY IN CO. KILDARE

FINAL REPORT

PREPARED BY AQUENS LTD.
OCTOBER 2015

INTRODUCTION

AQUENS Ltd. was commissioned by Environmental Protection Agency to undertake a biological assessment of the water quality of the Morell and Hartwell River, Co. Kildare to assess the potential impact the Kerdiffstown facility may be having on the Morell stream. A water quality assessment was undertaken at six sampling localities on the Morell River and one on the Hartwell stream to assess the upstream and downstream water quality as indicated by the benthic macroinvertebrate community. As the Hartwell River joins the Morell River adjacent to the Kerdiffstown facility the water quality of the Hartwell River and its influence in the Morell River had to be included to complete the water quality assessment. The same assessment was conducted in 2012 which assigned the Morell river a Q4, which indicated that there was no discernable impact arising from the facility. The national monitoring programme has shown that both these rivers have been impacted in the past with Q-values as low as Q3 recorded (www.epa.ie last accessed November 2015). The most recent water quality results (2013) indicate that the Morell river has deteriorated from 2012 with a Q3 above Kerdiffstown and improving to a Q3-4 ~1.5km below. Similarly the Hartwell had also deteriorated from 2012 and was assigned a Q3-4 in 2013.

MATERIALS & METHODS

The water quality assessment was undertaken using the benthic macroinvertebrates as bioindicators. These are an excellent tool for water quality assessment as they exhibit differential responses to physical and chemical changes in their environment. Some macroinvertebrates are sensitive to pollution while others are tolerant. They provide a realistic record of the prevailing water quality conditions.

On request of the client macroinvertebrate sampling took place on 11th October 2015. The same seven sites were sampled on the Morell and Hartwell Rivers to compare to a previous survey conducted (Baars & Kelly-Quinn, 2012). The sites were positioned to indicate the upstream and downstream water quality in relation to the facility (Figure 1). As the Hartwell River joins the Morell River along the length of the river that may be affected by the facility both upstream and downstream of the confluence were included (Plate 1M&H). One upstream site (M1) provides an indication of the water quality entering the area, and the other sites provided the progression downstream (M2 to M6) (Figure 1). One site (H1) provides the water quality status of the Harwell River (Figure 1), the location of the tributary and feeder streams of the constructed ponds on the golf course are not as indicated on the OSI maps. The indicative site characteristics are provided in Table 1 to assist in the interpretation of the water quality. These measurements do no provide an exhaustive account of the physical conditions of the sampling sites.

Table 1: Characteristics of the sampling sites on the Morell and Hartwell Rivers.

Sampling Site (OSI)	Width	Depth	T°C	DO	pH	Cond.	Dominant Substrates	In-stream Vegetation	Flow Conditions
Morell River									
M1 (N918 216)	3.6	0.55	9.9	10.28	7.74	602	Gravel, Sand (Fine & Course)	*Ranunculus* spp., *Fontinalis*, *Apium* & good marginal	Deep fast flowing run
M2 (N918 219)	3.1	0.35	9.5	15.03	8.12	604	Sand (F & C) some Gravel	Algae & little *Fontinalis* spp.	Shallow depositing, limited riffle
M3 (N918 220)	3	0.30	9.5	12.26	8.61	590	Gravel, Sand and some cobble	*Ranunculus* spp., *Fontinalis* spp., Filamentous algae	Fast shallow run & riffle
M4 (N915 222)	4.3	0.25	9.3	12.19	8.23	610	Cobble, Gravel & Sand	little *Fontinalis* spp.	Glide, Run & Riffle
M5 (N914 225)	4.4	0.30	9.5	12.89	8.43	620	Cobble, Gravel & Sand	little *Fontinalis* spp., *Apium nodiflorum*	Run & Riffle some glide
M6 (N916 227)	3.2	0.45	9.4	13.21	8.01	618	Cobble, Gravel & Sand	little *Fontinalis* spp.	Glide, Run & Riffle
Hartwell River									
H1 (N919 220)	3.0	0.32	9.4	12.46	8.20	531	Compact clay, Gravel and some Cobble & Boulders	Filamentous algae & *Fontinalis* sp.	Fast Riffle & Run

The sampling method adopted was that applied by the EPA in the national river monitoring programme (McGarrigle *et. al.*, 2002). Using an FBA (Freshwater Biological Association) pond net (1mm mesh), a 2-minute, multi-habitat kick-sample was taken at each site. In addition, one minute stone-washing was also undertaken. The samples were preserved in 70% IMS and processed in the laboratory. They were sorted in an illuminated tray and all the macroinvertebrates were identified to the appropriate taxonomic resolution using FBA taxonomic keys.

The macroinvertebrate data were used to derive a Q-value using the EPA methodology (McGarrigle *et al*., 2002). This Q-value system is a five point scale (Q1-Q5: with intermediate scores obtainable, e.g. Q3-4) based on the proportions of five groups of macroinvertebrates, with different pollution tolerances (Appendix A). Two other biotic indices (BMWP and ASPT) were calculated (See Appendix B). The BMWP score is based on the presence of pollution-tolerant to pollution-sensitive families. Each family is assigned a score. The BMWP score is the sum of these family scores. Families that are sensitive to pollution are assigned higher scores than pollution-tolerant families. A high overall score indicates that the water quality is good. The ASPT is determined by dividing the BMWP score by the number of scoring taxa yielding a score between 1 and 10, values >6 usually indicate good water quality. In addition, the taxon richness and the percentage of Ephemeroptera/Plecoptera/Trichoptera (%EPT) were determined.

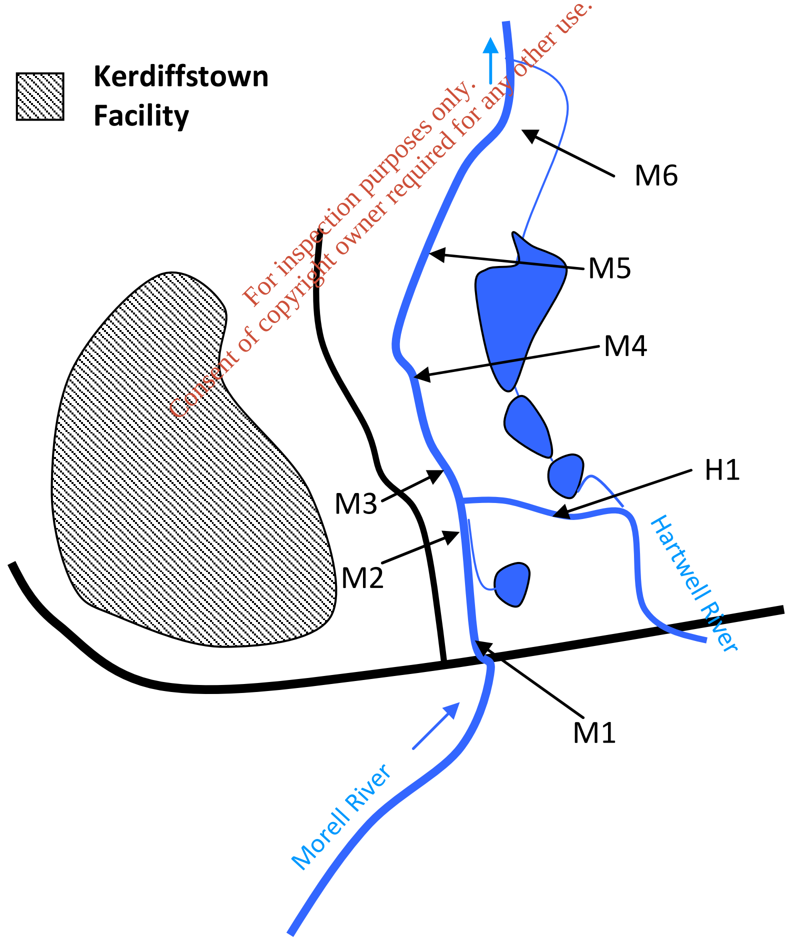


Figure 1: Schematic diagramme showing the location of sampling sites M1-6 on the Morell River and H1 on the Hartwell River in relation to the Kerdiffstown facility.

Plate 1: Sites assessed on the Morell (M) and Hartwell (H) Rivers adjacent to Kerdiffstown facility. M1 upstream, M2 upstream of two tributaries, M3 ~30m downstream of tributaries, M4, M5 & M6 further downstream, H1 50m before it joins the Morell River, M&H site where the Hartwell (left) and drainage ditch (right) joins the Morell River.

A range of physical (average depth and width, mesohabitat type and substrate composition) and chemical characteristics (dissolved oxygen, temperature, conductivity and pH) were determined on site using hand-held meters (Table 1).

RESULTS

Site Characteristics

As in the previous survey the banks of both rivers are disconnected from the adjacent habitat due to past flood relief/river redirection works. Most of the banks were at least >1m in height and steep sided. Most of the sites were relatively fast flowing with little in-stream vegetation, with the exception of *Fontinalis* sp., *Ranunculus* spp., liverworts and some filamentous algae (see Table 1). Most of the substrates were relatively clean but largely consolidated through calcification leaving little loose cobble and coarse gravel available for invertebrates. Sites did have accumulations of fine sand and sediments. Very few boulders were present and most sites appeared scoured. The water chemistry is indicative of the soil and geology in the area with high pH and conductivities (Table 1). Oxygen levels were within normal ranges (80-120%) with the exception of Site M2 & M6 (>120%).

Benthic Invertebrates

A total of 42 taxa were recorded during the survey, with individual sites recording between 19 and 30 taxa in the single, 2-minute kick sample taken at each site (Table 2). Overall the list of taxa were dominated in diversity by the less sensitive species, with only 17 taxa belonging to the Ephemeroptera, Plecoptera and Trichoptera (EPT) groups considered more pollution sensitive. In terms of abundance EPT made up the majority of the taxa at only four of the seven sites. One of the notable absences were the cased caddis (Trichoptera) as had been noted in the previous assessment (Baars and Kelly-Quinn, 2012), again probably as a result of the fast flow, embedded substrates and limited marginal vegetation (steep disconnected river banks) that usually offer sheltered microhabitats.

Water Quality

Several metrics were applied to the benthic invertebrates collected at each site. The Q-values were assigned on the basis of the sensitivity groups present in abundance, % representation and taxon richness (Table 3). It is clear that the two upstream sites (M1 & M2) have fewer Group A & B taxa present and a dominance of Group C. It is noteworthy that the substrate and habitats at both these sites were limited. Site M1 was deep largely dominated by embedded course gravel and cobble with very limited riffle habitat. Site M2 had some riffles present but largely dominated by fine sediment and where coarse substrates occurred these were largely embedded as a result of calcification. As a result of the lack of riffles and suitable substrates more time was spent sampling where suitable habitats occurred. This was taken into account when the Q-value assessment was done. At all the other sites there was enough suitable habitat/substrate to return a reliable sample.

Sites M1, M2 & M3 were assigned a Q3 and are thus moderately polluted. These three sites were dominated by Group C taxa with low abundances and diversity of Group A & B (Table 3 & Table 4). Site M3 is ~50m below the point at which the Hartwell river enters the Morell river. The site on the Hartwell was assigned a Q3-4, on the basis of the high proportion of Group C and relatively higher proportion of Group B. The Hartwell at this point is considered slightly polluted. All the sites further downstream on the Morell were assigned a Q 3-4 and are considered slightly polluted. The ASPT values are in broad alignment with the Q values (Table 4), with the exception of M4 & M5 which have a lower Q value assigned considering the ASPT values were 6.31 & 6.0 respectively. This was as a result of the low % abundance in Group B. The EPT were well represented in terms of their abundance, but were largely made up of those considered less sensitive, e.g. *Baetis rhodani* and *Hydropsyche* species.

Table 2: Benthic macroinvertebrate taxa recorded at each sampling site.

Order/Group	Family	Species/genus	M1	M2	M3	M4	M5	M6	H1
Crustacea	Asellidae	*Asellus aquaticus* (L.)	10	8	3	5	6	4	17
	Gammaridae	*Gammarus duebeni* (Lilj.)	297	47	55	31	102	62	15
	Astacidae	*Austropotamobius pallipes* (L.)				1			
Ephemeroptera	Baetidae	*Baetis rhodani* (Pictet.)	105	10	266	61	27	103	155
		Alianites muticus (L.)	3	2	5	5	3	1	1
	Ephemerelliidae	*Seratella ignita* (Poda)	2			2	2	1	
	Heptageniidae	*Ecdyonurus* spp.							2
		Rhithrogena semicolorata (Curtis)				1			3
Plecoptera	Leuctridae	*Leuctra fusca* L.			6	27	2	11	19
		Leuctra spp.					1	1	11
	Perlodidae	*Isoperla grammatica* (Poda)	3			1	1	1	1
	Neumoridae	*Protnemura meyeri* (Pictet)		1	1	1	1		
Trichoptera	Hydropsychidae	*Hydropsyche instabilis*	9	32	21	21	19	12	10
		H. fulvipes (Curtis)	9	4	9	10	6	16	10
		Hydropsyche sp.	41	26	195	285	39	204	217
	Polcentropodidae	*Plectrocnemia* spp.					1	1	1
	Psychomyiidae	*Lype phaeopa* (Stephens)		1	3	1			4
		Chaetopteryx villosa (Fab.)		1					
	Sericostomatidae	*Sericostoma personatum* (Spence)	1				3	9	
	Lepidostomatidae	*Lepidostoma hirtum* (Fabricius)		1		3	1		
	Hydroptilidae	*Hydroptilla* sp.					5		
Coleoptera	Elmidae	*Elmis aenea* (Müller)	14	12	15	52	14	147	6
		Oulimnius tuberculatus (Müller)					1		
		Limnius volckmari (Panzer)	9	4	5	19	4	17	4
		Esolus parallelepipedus (Müller)			33	55	26	45	
	Haliplidae	*Haliplus sp.*					1	2	
		Orectochilus villosus	2		1	6	5	9	3
Mollusca	Hyrobiidae	*Potamopyrgus antipodarum* (Gray)		4	4		4		1
	Lymnaeidae	*Lymnaea peregra* (Müller)		1					
Hirudinea	Erpobdellidae	*Erpobdella octoculata* (L.)							17
Diptera	Chironomidae	spp. indet.	23	7	111	2	3	13	
	Simuliidae	spp. indet.	27	3	51			6	11
	Tipulidae	*Tipula* spp.							11
	Pedicidae	*Dicranota* spp.	1	1	5	15	11	11	72
	Limonidae	*Antocha* spp.	1		5	10	8	37	2
	Empedidae	spp. indet.	6	2	4		12	2	3
	Muscidae	*Limnophora* spp.			2			2	2
	Ceratapogonidae	spp. indet.				1	1		1
	Dixidae	Dixa spp.	2	1			2		
	Psychodidae	spp. indet.				1			
Oligochaeta	Oligochaeta indet.	spp. indet.	6	13	4	31	11	9	9
		Einsella		2	2	2	2	1	
Arachnida	Hydracarnia	spp. indet.	2				2		

Table 3: The representation of each invertebrate group as separated by the Q-value system in each of the sampling sites on Morell (M1-6) and Hartwell (H1) rivers.

Q-value Grouping	M1	M2	M3	M4	M5	M6	H1
Total Abundance							
Group A	3	1	1	4	2	1	6
Group B	4	4	11	35	15	22	31
Group C	548	154	785	572	288	690	528
Group D	16	24	9	38	19	14	43
Group E	0	0	0	0	0	0	0
% Abundance							
Group A	0.5	0.5	0.1	0.6	0.6	0.1	1.0
Group B	0.7	2.2	1.4	5.4	4.6	3.0	5.1
Group C	96.0	84.2	97.4	88.1	88.9	94.9	86.8
Group D	2.8	13.1	1.1	5.9	5.9	1.9	7.1
Group E	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Number of Taxa							
Group A	1	1	1	4	2	1	3
Group B	2	3	2	3	6	4	3
Group C	14	13	16	15	19	17	17
Group D	2	4	3	3	3	3	3
Group E	0	0	0	0	0	0	0

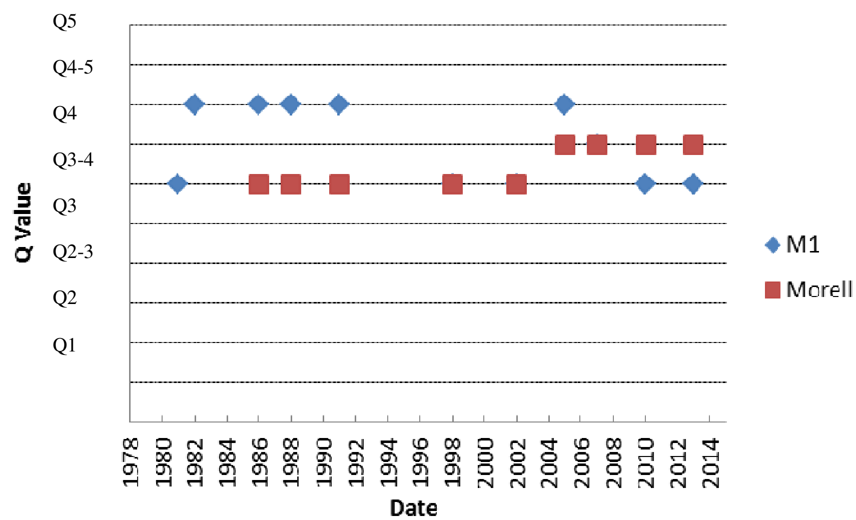
Table 4: Water quality scores, metric scores and invertebrate richness and abundances for 7 sampling sites on Morell (M1-6) and Hartwell (H1) rivers.

	M1	**M2**	**M3**	**M4**	**M5**	**M6**	**H1**
Q value	Q3	Q3	Q3	Q3-4	Q3-4	Q3-4	Q3-4
BMWP	71	74	69	101	109	88	90
ASPT	5.46	4.93	4.93	6.31	6.06	5.87	5.63
Scoring	13	15	14	16	18	15	16
EPT Taxa (%)	30.3	42.6	62.8	64.4	34.3	49.5	71.4
Taxon Richness	19	21	22	25	30	25	26
Total Abundance	571	183	806	649	324	727	608

CONCLUDING COMMENTS

Both these rivers have been modified in the past (flood relief & urbanisation) and are quite disconnected from the riparian habitats and river banks. The steep banks, the lack of natural sinuosity as a result of past modification and rhithral nature of these rivers have resulted in very limited marginal habitats. The steep sides and linear nature are likely to have increased the flow which has led to the stretches under investigation being scoured with limited amounts of cobbles and boulders available for invertebrate colonisation. Both rivers are also high in calcium carbonate which has led to the substrates being embedded through calcium precipitation. It would be expected that as a result of these factors the community would be under stress and highly heterogeneous in spatial distribution. However, these two rivers can support a high density and diversity of sensitive taxa as indicated by the 2012 survey and earlier surveys conducted by the EPA (Hartwell Q4-5 in 2002/5 and Q5 in 1980, and Morell Q4 in 1982-1991 & 2005)(see Figure 2).

The results of this assessment indicate that both rivers are impacted. The Morell river is moderately polluted upstream of the Kerdiffstown facility and then improves to slightly polluted some distance after the confluence with Hartwell river. The Morell river has a larger volume and it seems that the Q3-4 water quality from the Hartwell river only improves the water quality status in the Morell river some distance downstream of the confluence. It is likely that this and possible recharge from groundwater is improving the water quality downstream. Because the river maintains a Q3-4 status while it passes the Kerdiffstown facility there is no indication that the facility is having a discernable impact on the water quality status of the Morell river.



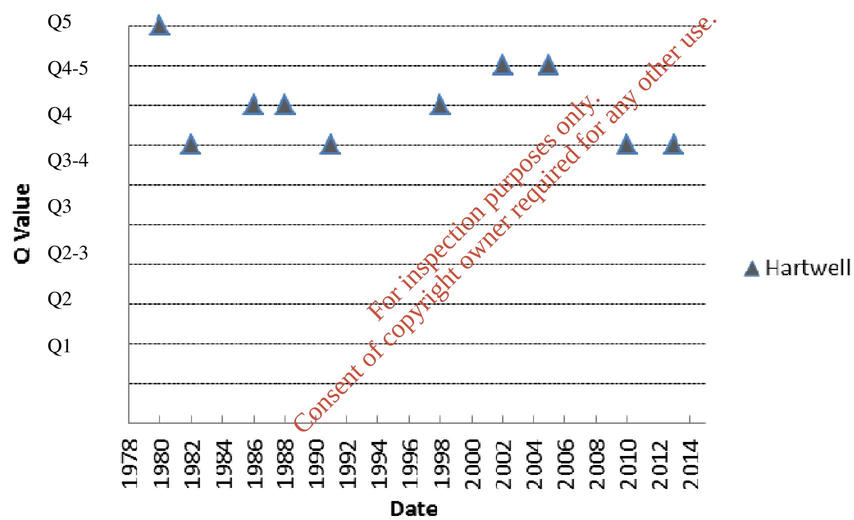


Figure 2: Historical EPA water quality data on the Morell and Hartwell rivers. Sites on Morell refer to same upstream site as one assessed in present survey and Morell refers to site 1.5km downstream of the facility. Site on Hartwell river about 500m upstream of H1 in present study.

It is concerning that in such a short period the Morell and Hartwell river have deteriorated in water quality since the 2012 survey (Baars and Kelly-Quinn, 2012). However, it seems indicative of this catchment because the water quality of both these rivers has been fluctuating over many years according to the data available from the EPA river monitoring programme. As indicated in Figure 2 the Morell has fluctuated between Q3 and Q4 and Hartwell between Q3-4 and Q5 over last 30 years. Due to their low volume I is likely these rivers are vulnerable to low volume of inputs.

Based on the results of the survey conducted, there is no indication that the Kerdiffstown facility is causing a discernible impact on the Morell river as it passes the area. With a moderately polluted water status small changes in water quality as a result of the Kerdiffstown facility will be difficult to detect. It is advisable that the water quality assessment is done regularly and that the assessments be conducted in the summer months (towards early summer, i.e. May-June). In order to detect potential impact of the groundwater other biological indicators should be considered. These could include 1) a population density assessment of key taxa (to include sensitive and less sensitive taxa), 2) heavy metal bioaccumulation in the freshwater shrimp *Gammarus deubeni*, 3) assessment of the fish tissues for bioaccumulation of heavy metals.

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Appendix A: Macroinvertebrates grouped according to their sensitivity to organic pollution (taken from McGarrigle *et al.,* 2002).

Macroinvertebrates grouped according to their sensitivity to organic pollution					
TAXA	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**
	Sensitive	*Less Sensitive*	*Tolerant*	*Very Tolerant*	*Most Tolerant*
Plecoptera	All except *Leuctra* spp.	*Leuctra* spp.			
Ephemeroptera	Heptageniidae Siphlonuriidae *Ephemera danica*	Baetidae (excl. *Baetis rhodani*) Leptophlebidae	*Baetis rhodani* Caenidae Ephemerellidae		
Trichoptera		Cased spp.	Uncased spp.		
Odonata		All taxa			
Megaloptera				Sialidae	
Hemiptera		***Aphelocheirus aestivalis***	All except *A. aestivalis*		
Coleoptera			Coleoptera		
Diptera			Chironomidae (excl. *Chironomus* spp.) Simuliidae Tipulidae		*Chironomus* spp. *Eristalis* sp.
Hydracarina			Hydracarina		
Crustacea			*Gammarus* spp. *Austropotamobius pallipes*	*Asellus* spp. *Crangonyx* spp.	
Gastropoda			Gastropoda (excl. *Lymnaea peregra* & *Physa* sp.)	*Lymnaea peregra* *Physa* sp.	
Lamellibranchiata	***Margaritifera margaritifera***		*Anodonta* spp.	Sphaeriidae	
Hirudinea			*Piscicola* sp.	All except *Piscicola* sp.	
Oligochaeta					Tubificidae
Platyhelminthes			All		

Biological Assessment of Water Quality in Eroding Reaches (Riffles & Glides) of Rivers and Streams*						
Biotic Indices (Q Values) and typical associated macroinvertebrate community structure. See overleaf for details of the Faunal Groups.						
Macroinvertebrate Faunal Groups**	**Q5**	**Q4**	**Q3-4**	**Q3**	**Q2**	**Q1**
Group A	At least 3 taxa well represented	At least 1 taxon in reasonable numbers	At Least 1 taxon Few - Common	Absent	Absent	Absent
Group B	Few to Numerous	Few to Numerous	Few/Absent to Numerous	Few/Absent	Absent	Absent
Group C	Few	Common to Numerous *Baetis rhodani* often Abundant Others: never Excessive	Common to Excessive (usually Dominant or Excessive)	Dominant to Excessive	Few or Absent	Absent
Group D	Few or Absent	Few or Absent	Few/Absent to Common	Few/Absent to Common	Dominant to Excessive	Few or Absent
Group E	Few or Absent	Few or Absent	Few or Absent	Few or Absent	Few / Absent to Common	Dominant
Additional Qualifying Criteria						
Cladophora spp. Abundance	Trace only or None	Moderate growths (if present)	May be Abundant to Excessive growths	May be Excessive growths	Few or Absent	None
Macrophytes (Typical abundance)	Normal growths or absent	Enhanced growths	May be Luxuriant growths	May be Excessive growths	Absent to Abundant	Present/Absent
Slime Growths (Sewage Fungus)	Never	Never	Trace or None	May be Abundant	May be Abundant	None
Dissolved Oxygen Saturation	Close to 100% at all times	80% - 120%	Fluctuates from < 80% to >120%	Very unstable. Potential fish-kills	Low (but > 20%)	Very low, sometimes zero
Substratum Siltation	None	May be light	May be light	May be considerable	Usually heavy	Usually very heavy and anaerobic

Note occurrence/abundance of groups in above table refers to <u>some</u> but not necessarily <u>all</u> of the constituents of the group. The Additional Qualifying Criteria apply in virtually all circumstances. Single specimens may be ignored. Seasonal and other relevant factors (i.e., drought, floods) must be taken into account.

* Macroinvertebrate criteria do not apply to rivers with mud, bedrock or sand substrata, very sluggish or torrential flow, head-water or high altitude streams and those affected by significant ground water input, excessive calcification, drainage, canalisation, culverting, marked shading etc.

** See Further Observations overleaf.

Appendix A cont.: Abundance categories and interpretation of macroinvertebrate survey results.

Table 3 Abundance categories and relationship to percentage frequency of occurrence (After McGarrigle *et al*., 2002).

Abundance Category	Approx. percentage frequency of occurrence
Absent	no specimens
Present	1 or 2 individuals
Scarce/few	<1% of the total fauna
Small numbers	<5%
Fair Numbers	5-10%
Common	10-20%
Numerous	25 -50%
Dominant	50 -75%
Excessive	>75%

Table 4 Interpretation of quality ratings (After McGarrigle *et al.,* 2002).

Quality ratings	Pollution status
Q5, Q4-5 and Q4	Unpolluted
Q3-4,	Slightly polluted
Q3 and Q2-3	Moderately polluted
Q2, Q1-2 and Q1	Serious pollution

APPENDIX B: BMWP (Biological Monitoring Working Party) Score (after Armitage *et al.,* 1983).

Families	Score
Siphlonuridae, Heptageniidae, Ephemerellidae, Leptophlebiidae, Potamanthidae, Ephemeridae, Taeniopterygidae, Leuctridae, Capniidae, Perlididae, Chloroplidae, Aphelocheiridae, Phyrganidae, Molannidae, Beraeidae, Odontoceridae, Leptoceridae, Goeridae, Lepidostomatidae, Brachycentridae, Sericostomatidae, Perlodidae	10
Astacidae, Lestidae, Agriidae, Gomphidae, Cordulegarsteridae, Aeshnidae, Cordulliidae, Libellulidae, Psychomyidae, Philopotamidae	8
Caenidae, Nemouridae, Rhyacophilidae, Polycentropodidae, Limnephilidae	7
Neritidae, Viviparidae, Ancylidae, Hydroptilidae, Unionidae, Corophidae, Gammaridae, Platycnemididae, Coenagriidae	6
Mesovelidae, Hydrometridae, Gerridae, Nepidae, Naurcoridae, Notonectidae, Pleidae, Corixidae, Halipildae, Hygrobiidae, Dytiscidae, Gyrinidae, Hydrophilidae Clambeidae, Helodidae, Dryopidae, Elmidae, Chrysomelidae, Curculonidae, Hydropschyidae, Tipulidae, Simuliidae, Planariidae, Dendrocoelidae	5
Baetidae, Sialidae, Piscicolidae	4
Valvatidae, Hydrobiidae, Lymnaeidae, Physidae, Planorbidae, Sphaeridae, Glossophoniidae, Hirudinidae, Eropbellidae, Asellidae	3
Chironomidae	2
Oligochaeta	1

**WATER QUALITY ASSESSMENT
OF THE MORELL AND HARTWELL RIVERS ADJACENT TO THE
KERDIFFSTOWN FACILITY IN CO. KILDARE**

FINAL REPORT

**PREPARED BY AQUENS LTD.
SEPTEMBER 2016**

INTRODUCTION

AQUENS Ltd. was commissioned by Kildare County Council to undertake a biological assessment of the water quality of the Morell and Hartwell Rivers, Co. Kildare to assess the potential impact the Kerdiffstown facility may be having on the Morell River. A water quality assessment was undertaken at eight sampling localities on the Morell River and two on the Hartwell stream to assess the upstream and downstream water quality as indicated by the benthic macroinvertebrate community. The Hartwell River joins the Morell River adjacent to the Kerdiffstown facility and therefore the water quality had to be assessed to determine its influence on the Morell River.

Most of the sites were previously monitored in 2012 and 2015 at which time the quality rating indicated that the Morell upstream of the facility was moderately polluted and improved to slightly polluted once the Hartwell joined the Morell River. The results showed that the facility had no discernible impact on the biological quality of the Morell River. Upstream sources of pollution meant that the Morell River was already impacted upstream of the Kerdiffstown landfill and no further impact was detected in 2015. in addition, the quality improved further downstream of the facility, probably as a result of the dilution effect of the Hartwell River on the Morell River. An additional two sites on the Morell and one on the Hartwell River were monitored in the present survey to determine the water quality further upstream and assess the extent of the impacted stretch.

The national monitoring programme conducted by the Environmental Protection Agency (EPA) has shown that both these rivers have been impacted in the past with Q-values as low as Q3 recorded (www.epa.ie last accessed November 2015). The most recent water quality results (2013) indicate that the Morell River has deteriorated from 2012 with a Q3 recorded above Kerdiffstown and improving to a Q3-4 ~1.5km below. Similarly the Hartwell River had also deteriorated from 2012 and was assigned a Q3-4 in 2013.

MATERIALS & METHODS

The water quality assessment was undertaken using the benthic macroinvertebrates as bioindicators. These are standard bioindicators of water quality as the various taxa exhibit differential responses to physical and chemical changes in their environment and the composition reflects the extent of environmental change. Some macroinvertebrates are sensitive to pollution while others are tolerant and the percentage composition of the community provides a realistic record of the prevailing water quality conditions (as an integrated signal of relatively long water quality conditions).

On request of the client macroinvertebrate sampling took place on 23rd June 2016. The same seven sites were sampled on the Morell and Hartwell Rivers to compare to previous surveys conducted in 2012 and 2015 (Baars & Kelly-Quinn, 2012; 2015). Three additional sites were added in the present survey (2016), and included two further upstream on the Morell River (M7 & M 8) 1km upstream of M1 and one on the Hartwell River (H2) above H1. The sites were chosen to represent the upstream water quality and to help interpret the proximity of the source of upstream pollution sources (Figure 1). Because the Hartwell River joins the Morell River along the length of the river that may be affected by the Kerdiffstown facility the Hartwell had to be included to determine its influence on the water quality of the Morell River. As a result three sites (M1, M7 & M8) provided an indication of the water quality entering the area immediately upstream, and the other sites provided the progression downstream (M2 to M6) (Figure 1). Two sites (H1 & H2) provided an indication of the water quality status of the Harwell River (Figure 1). The location of the tributary and feeder streams of the constructed ponds on the golf course are not as indicated on the OSI maps but no other natural or man-made surface runoff point enters the Morell River along the length assessed. The Hartwell River enters the Morell River directly below sampling site M2. The indicative site characteristics are provided in Table 1 to assist in the interpretation of the water quality. These measurements do no provide an exhaustive account of the physical conditions of the sampling sites.

Table 1: Characteristics of the sampling sites on the Morell and Hartwell Rivers.

Sampling Site (OSI)	Width	Depth	T°C	DO	pH	Cond.	Dominant Substrates	In-stream Vegetation	Flow Conditions
Morell River									
M1 (N918 216)	2.8	0.50	14.3	10.65	8.84	622	Gravel (fine & course)	*Ranunculus* spp., *Fontinalis*, *Apium* & good marginal	Deep fast flowing run
M2 (N918 219)	4.9	0.35	14.4	10.25	8.82	637	Sand (F & C) some gravel, large parts consolidated	Algae & little *Fontinalis* spp.	Shallow depositing, limited riffle
M3 (N918 220)	3.9	0.26	14.7	10.34	8.92	598	Gravel, sand and some cobble	*Ranunculus* spp., *Fontinalis* spp., Filamentous algae	Fast shallow run & riffle
M4 (N915 222)	5.4	0.26	14.6	10.31	8.93	613	Cobble, gravel & sand	little *Fontinalis* spp.	Glide, Run & Riffle
M5 (N914 225)	4.9	0.31	14.4	10.34	8.64	628	Cobble, gravel & sand	little *Fontinalis* spp., *Apium nodiflorum*	Run & Riffle some glide
M6 (N916 227)	3.4	0.43	14.3	10.43	7.48	605	Cobble, gravel & sand	little *Fontinalis* spp.	Glide, Run & Riffle
M7 (926 204) ~1km upstream of M1	1.5	0.21	14.8	10.88	8.92	667	Course gravel dominated and some cobble, mostly consolidated substrate	Some *Fontinalis*	Mostly glide/run, minimal Riffle
M8 (913 204) ~1km upstream of M1	2.8	0.24	12.6	10.01	8.55	619	Cobble course gravel dominated, some fine sediment and consolidated sections	Large *Apium* beds, some liverworts and *Fontinalis* spp.	Run/Glide and some deep riffle
Hartwell River									
H1 (N919 220)	4.1	0.25	15.9	9.95	8.95	541	Compact clay, gravel and some cobble & boulders	Filamentous algae & *Fontinalis* sp., *Glyceria* on margins	Fast Riffle & Run
H2 (N926 218)	2.4	0.13	15.9	9.82	8.93	545	Cobble, course gravel dominated with some boulders	Considerable algal growth, marginal Glyceria and *V. becabunga*	Fast riffle & Run

The sampling method adopted was that applied by the EPA in the national river monitoring programme (McGarrigle *et. al.*, 2002). Using an FBA (Freshwater Biological Association) pond net (1mm mesh), a 2-minute, multi-habitat kick-sample was taken at each site. In addition, one minute stone-washing was also undertaken. The samples were preserved in 70% IMS and processed in the laboratory. They were sorted in an illuminated tray and all the macroinvertebrates were identified to the appropriate taxonomic resolution using FBA taxonomic keys.

The macroinvertebrate data were used to derive a Q-value using the EPA methodology (McGarrigle *et al*., 2002). This Q-value system is a five point scale (Q1-Q5: with intermediate scores obtainable, e.g. Q3-4) based on the proportions of five groups of macroinvertebrates, with different pollution tolerances (Appendix A). Two other biotic indices (BMWP and ASPT) were calculated (See Appendix B). The BMWP score is based on the presence of pollution-tolerant to pollution-sensitive families. Each family is assigned a score. The BMWP score is the sum of these family scores. Families that are sensitive to pollution are assigned higher scores than pollution-tolerant families. A high overall score indicates that the water quality is good. The ASPT is determined by dividing the BMWP score by the number of scoring taxa yielding a score between 1 and 10, values >6 usually indicate good water quality. In addition, taxon richness and the percentage of Ephemeroptera/Plecoptera/ Trichoptera (%EPT) were determined.

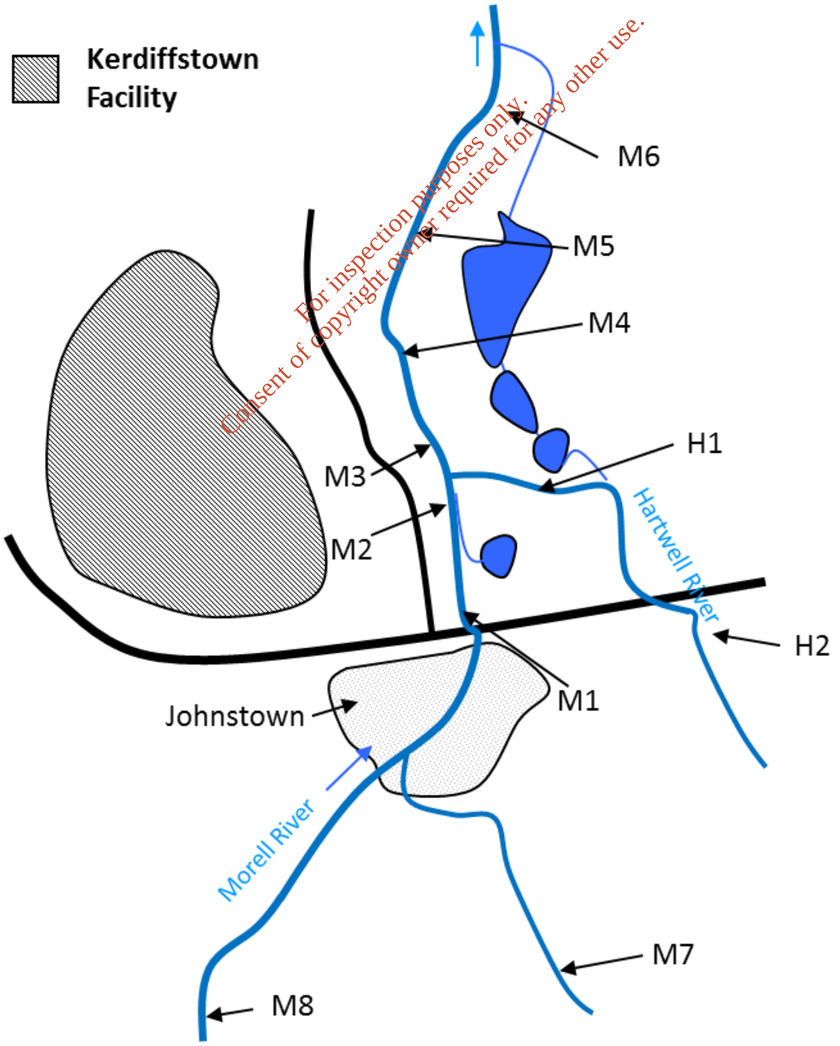


Figure 1: Schematic diagramme showing the location of sampling sites M1-8 on the Morell River and tributary and H1 & H2 on the Hartwell River in relation to the Kerdiffstown facility.

Plate 1: Sites assessed on the Morell River (M) adjacent to the Kerdiffstown facility. M7, tributary upstream, M8 Morel upstream, M1 upstream & downstream of Johnstown, M2 upstream of confluence with Hartwell River, M3 ~30m downstream of Hartwell River confluence, M4 further downstream.

Plate 2: Sites assessed on the Morell (M) and Hartwell (H) Rivers adjacent to the Kerdiffstown facility. M5 & M6 further downstream on Morell River. H1 50m before it joins the Morell River, H2 East of M7 motorway on the Hartwell River.

A range of physical (average depth and width, mesohabitat type and substrate composition) and chemical characteristics (dissolved oxygen, temperature, conductivity and pH) were determined on site using hand-held meters (Table 1).

RESULTS

Site Characteristics

As in the previous survey the banks of both rivers are disconnected from the adjacent habitat due to past flood relief/river redirection works. Most of the banks were at least >1m in height and steep sided. Flow was relatively fast at most of the sites with little in-stream vegetation, with the exception of *Fontinalis* sp., *Ranunculus* spp., liverworts and some filamentous algae (see Table 1).

Most of the substrates were relatively clean but largely consolidated through calcification leaving little loose cobble and coarse gravel available for invertebrates. Sites did have accumulations of fine sand and sediments. Very few boulders were present and most sites appeared scoured. The water chemistry is indicative of the soil and geology in the area with alkaline pH and high conductivities (Table 1). Oxygen levels were within normal ranges (80-120%) with the exception of Site M2 & M6 (>120%).

Benthic Invertebrates

A total of 42 taxa were recorded during the survey, with individual sites recording between 19 and 30 taxa in the single, 2-minute kick sample taken at each site (Table 2). Overall the list of taxa was dominated in diversity by the less sensitive species, with only 17 taxa belonging to the Ephemeroptera, Plecoptera and Trichoptera (EPT) groups considered more pollution sensitive. In terms of abundance EPT made up the majority of the taxa at only four of the seven sites.

One of the notable absences were the cased caddis (Trichoptera) as had been noted in the previous assessment (Baars and Kelly-Quinn, 2012), again probably as a result of the fast flow, embedded substrates and limited marginal vegetation (steep disconnected river banks) that usually offer sheltered microhabitats.

Water Quality

The taxa recorded and their abundances at each site are presented in Table 2. Several metrics were applied to the benthic invertebrate taxa collected at each site. The Q-values were assigned on the basis of the sensitivity groups present in abundance, % representation and taxon richness (Table 3). The majority of the sites on both the Morell and Hartwell Rivers have either few or no Group A taxa, a small percentage of group B taxa present and a dominance of Group C. As a result the sites were assigned either a Q3 or Q3-4 indicating moderate to slight pollution.

Sites M1, M2 & M3 were assigned a Q3 and are thus moderately polluted. These three sites were dominated by Group C taxa, no Group A taxa present and a low percentage representation and diversity of Group B (Table 3 & Table 4). The two upstream sites (M7 & M8) about 1km above M1 on the Morell River were assigned a Q3-4 indicating slight pollution. These indicate that the Morell River deteriorates either directly above Johnstown or as a result of inputs coming from Johnstown. The Q3 status at M1 indicates that the river is moderately impacted before any potential impact arising from the Kerdiffstown facility.

The sampling sites on the Hartwell River were both assigned a Q3-4, on the basis of the high proportion of Group C and relatively higher proportion of Group B with some Group A taxa present. The Hartwell River before entering the Morell River is therefore considered slightly polluted, but has better water quality than the upstream sites on the Morell River including M2 (directly above the confluence of the Morell and Hartwell Rivers) which was assigned a Q3. Directly below the confluence the Morell River (site M3) was still assigned a Q3 (Table 4) but all the other sites further downstream on the Morell River were assigned a Q 3-4 and are considered slightly polluted. The Hartwell River is diluting pollutants in the Morell River and improving the status downstream. The other metrics including the ASPT and EPT are in line with the Q values assigned but indicate that M7 & M8 are on the low side of Q3-4 possibly indicating that the Hartwell is in a better ecological status than the upper stretches of the Morell River. The ASPT values of M7 and M8 were 5.67 and 5.5 respectively. The EPT were well represented in terms of their abundance, but were once again largely made up of those considered less sensitive, e.g. *Baetis rhodani*, *Seratella ignita* and *Hydropsyche* species.

Table 2: Benthic macroinvertebrate taxa recorded at each of the ten sampling sites.

Group	Family	Species/genus	M1	M2	M3	M4	M5	M6	H1	H2	M7	M8
Crustacea	Asellidae	*Asellus aquaticus* (L.)		4	3	4	3	3	1	3	4	2
	Gammaridae	*Gammarus duebeni* (Lilj.)	255	108	222	156	160	81	372	308	140	384
	Astacidae	*Austropotamobius pallipes* (L.)					1	1				
Ephemeroptera	Baetidae	*Baetis rhodani* (Pictet.)	17	1	37	14	4	4	11	73	3	63
		Alianites muticus (L.)				2	1		1			2
	Ephemerelliidae	*Seratella ignita* (Poda)	313	171	534	290	303	295	221	767	99	231
	Eohemeridae	*Ephemera danica* Muller					1	2			2	
	Heptageniidae	*Rhithrogena semicolorata* (Curtis)							1			
	Leptophlebidae	*Paraleptophlebia* spp.				1						
Plecoptera	Leuctridae	*Leuctra fusca* (L.)					1		3	2		
Trichoptera	Hydropsychidae	*Hydropsyche instabilis* (Curtis)	5	15	10	28	18	8	15	7	37	
		Hydropsyche fulvipes (Curtis)	3	9	6	15	6	4	4	3	19	
	Rhyacophilidae	*Rhyacophila dorsalis* (Curtis)		1	3	5	1	1		2	4	
	Limnephilidae	*Micropterna sequax* McLachlan	1			1	1			2	1	2
		Drusus annulatus (Stephens)				2	1		4	31	5	14
		Chaetopteryx villosa (Fab.)	1									
	Sericostomatidae	*Sericostoma personatum* (Spence in K & S)		2			3	3			4	1
Coleoptera	Elmidae	*Elmis aenea* (Müller)			4	2	1		4	4	8	
		Limnius volckmari (Panzer)			3				3	2	4	
		Esolus parallelepipedus (Müller)									2	
Mollusca	Sphaeriidae	*Sphaerium/Pisidium* spp.					1					
	Lymnaeidae	*Lymnaea peregra* (Müller)		1							1	
Hirudinea	Erpobdellidae	*Erpobdella octoculata* (L.)	1	4						5	4	3
Diptera	Chironomidae	spp. indet.	8	2	45	35	40	13	7	14	30	15
	Simuliidae	spp. indet.	57	40	177	45	4	54	126	324	68	36
	Pedicidae	*Dicranota* spp.	1		1		2			1	1	2
	Empedidae	spp. indet.		1							1	
Oligochaeta	Oligochaeta	spp. indet.	1	9	3			3	1			3
		Eiseniella spp.				4	4					

Table 3: The representation of each invertebrate group as separated by the Q-value system in each of the sampling sites on Morell (M1-6) and Hartwell (H1) Rivers.

Sensitivity grouping	M1	M2	M3	M4	M5	M6	H1	H2	M7	M8
Total Abundance										
Group A	0	0	0	3	3	3	2	0	2	2
Group B	2	2	0	3	6	3	7	35	10	17
Group C	659	348	1042	590	539	460	763	1505	416	731
Group D	2	18	6	8	8	6	2	8	9	8
Group E	0	0	0	0	0	0	0	0	0	0
Percentage Abundance										
Group A	0.0	0.0	0.0	0.5	0.5	0.6	0.3	0.0	0.5	0.3
Group B	0.3	0.5	0.0	0.5	1.1	0.6	0.9	2.3	2.3	2.2
Group C	99.4	94.6	99.4	97.7	96.9	97.5	98.6	97.2	95.2	96.4
Group D	0.3	4.9	0.6	1.3	1.4	1.3	0.3	0.5	2.1	1.1
Group E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Number of Taxa										
Group A	0	0	0	2	3	2	2	0	1	1
Group B	2	1	0	2	4	1	2	3	3	3
Group C	8	9	11	9	10	8	9	11	13	6
Group D	2	4	2	2	3	2	2	2	3	3
Group E	0	0	0	0	0	0	0	0	0	0

Table 4: Water quality scores, metric scores and invertebrate richness and abundances for 8 sampling sites on Morell (M1-8) and two on Hartwell (H1 & H2) Rivers respectively.

	M1	M2	M3	M4	M5	M6	H1	H2	M7	M8
Q value	Q3	Q3	Q3	Q3-4	Q3-4	Q3-4	Q3-4	Q3-4	Q3-4	Q3-4
BMWP	48	59	53	64	92	62	67	72	85	55
ASPT	4.8	4.92	4.82	5.82	6.13	6.2	6.09	5.54	5.67	5.5
Scoring	10	12	11	11	15	10	11	13	15	10
EPT Taxa (%)	51.3	54.1	56.3	59.3	61.2	67.2	33.6	57.3	39.8	41.3
Taxon Richness	14	17	15	17	19	16	17	17	22	15
Total Abundance	663	368	1048	604	556	472	774	1548	437	758

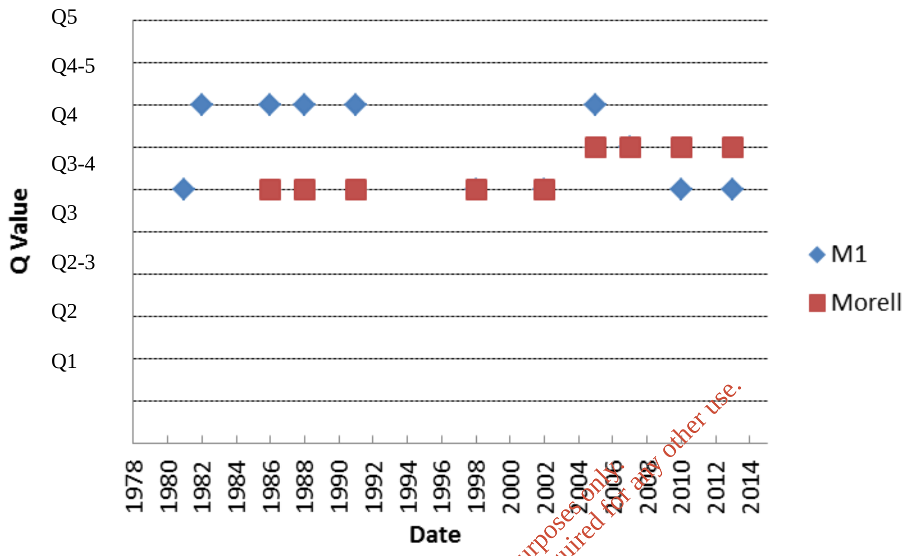
CONCLUDING COMMENTS

Both the Hartwell and Morell Rivers have been modified in the past (flood relief & urbanisation) and are quite disconnected from the riparian habitats and river banks. The steep banks, the lack of natural sinuosity as a result of past modification and the rhithral nature of these rivers have resulted in very limited marginal habitats. The steep sides and linear nature are likely to have increased the flow which has led to the stretches under investigation being scoured leaving small amounts of cobbles and boulders within the river channel available for invertebrate colonisation. Both rivers are also high in calcium carbonate which has led to the substrates being embedded through calcium carbonate precipitation. It would be expected that as a result of these factors the community would be under stress and highly heterogeneous in spatial distribution.

However, there are patches of suitable substrates and in-stream habitat (fast and slow flowing riffles) that should support a range of invertebrate species, and in the past both the Morell and Hartwell Rivers have supported a high density and diversity of sensitive taxa as indicated by the 2012 survey and earlier surveys conducted by the EPA (Hartwell Q4-5 in 2002/5 and Q5 in 1980, and Morell Q4 in 1982-1991 & 2005)(see Figure 2, page 13).

The results of this assessment indicate that both rivers are impacted. The Morell River is slightly polluted in the upper stretches (M7 & 8) but is moderately polluted directly upstream of the Kerdiffstown facility (M1). As the Morell River flows alongside the facility the status remains as a Q3 until the Hartwell River joins and appears to dilute the Morell River. The two sampling sites on the Hartwell River indicate that the biological quality is slightly better than that of the Morell River and therefore is improving the quality of the Morell River. Based on the other metrics (slightly higher ASPT) the community does have more sensitive taxa present and from past observations on the Hartwell River (site H2) there are sensitive taxa that occur in Spring in the Hartwell River including several Plecoptera (e.g. *Isoperla grammatical*, *Brachyoptera risi*, *Siphonoperla torrentium, Leuctra inermis* and *L. hippopus*).

The present survey indicates that the Hartwell River only has a diluting effect on the Morell River by site M4 where Q3-4 rating was assigned. The Morell River was slightly polluted from this point on including both sites M5 and M6. Because the water quality improved to a Q3-4 after the Hartwell River joined the Morell River there is no evidence from the benthic invertebrates that the Kerdiffstown facility is significantly affecting the community composition in the Morell River.



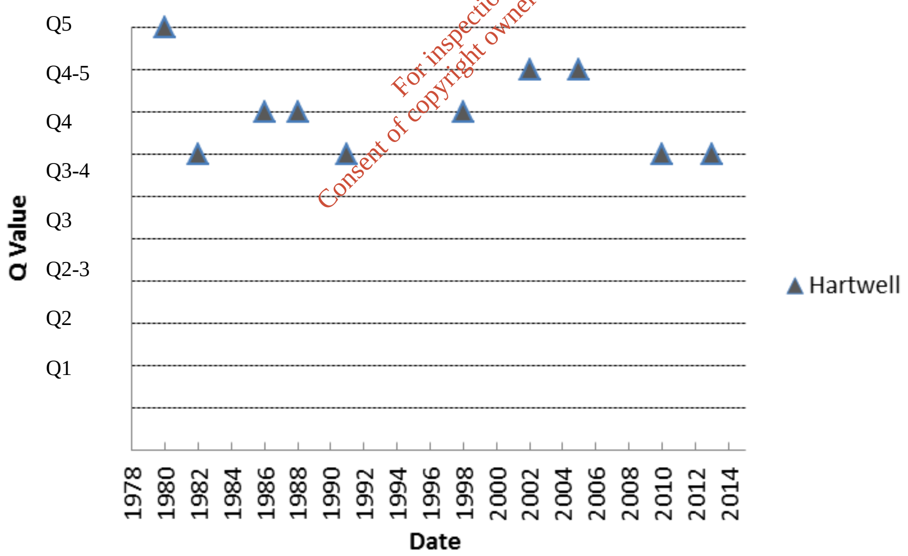


Figure 2: Historical EPA water quality data on the Morell and Hartwell rivers. Sites on Morell refer to same upstream site as one assessed in present survey and Morell refers to site 1.5km downstream of the facility. Site on Hartwell River about 500m upstream of H1 and 150m downstream of H2 in the present study.

The present survey (2016) indicates that the recent deterioration observed in the Morell and Hartwell Rivers since 2012 (Baars and Kelly-Quinn, 2012) is still maintained. The upstream stretches of both rivers, particularly on the Morell River are slightly impacted indicating that there are multiple sources of pressures that need to be addressed in order to improve the quality of these rivers. The present survey indicates that there is a significant pollution pressure either directly above or arising from Johnstown lowering the ecological quality of the Morell River before it gets to the Kerdiffstown facility. Water quality in both of these rivers has been fluctuating over many years according to the data available from the EPA river monitoring programme. As indicated in Figure 2 the Morell has fluctuated between Q3 and Q4 and Hartwell between Q3-4 and Q5 over the last 30 years. Due to their low water volume it is likely these rivers are vulnerable to even low volume of pollution inputs.

Based on the results of the survey conducted, there is no indication that the Kerdiffstown facility is causing a discernible impact on the Morell River as it passes the area. With an upstream status of moderately polluted (Q3) and a slightly polluted status along the lower stretches small changes in water quality that may be arising from the Kerdiffstown facility would theoretically be difficult to detect. Regular monitoring would be advisable, particularly timed to coincide with late spring or early summer (April-June). To assess any likely specific pollutants arising from the facility, if indicated by the water chemistry of the boreholes, other additional monitoring may be considered (given that the Morell River is moderately-slightly polluted upstream) that include 1) a population density assessment of key taxa (to include sensitive and less sensitive taxa), 2) heavy metal bioaccumulation in the freshwater shrimp *Gammarus deubeni*, 3) assessment of the fish tissues for bioaccumulation of heavy metals (although fish are highly mobile).

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Appendix A: Macroinvertebrates grouped according to their sensitivity to organic pollution (taken from McGarrigle *et al.*, 2002).

Biological Assessment of Water Quality in Eroding Reaches (Riffles & Glides) of Rivers and Streams*

Biotic Indices (Q Values) and typical associated macroinvertebrate community structure. See overleaf for details of the Faunal Groups.

Macroinvertebrate Faunal Groups**	Q5	Q4	Q3-4	Q3	Q2	Q1
Group A	At least 3 taxa well represented	At least 1 taxon in reasonable numbers	At least 1 taxon Few - Common	Absent	Absent	Absent
Group B	Few to Numerous	Few to Numerous	Few/Absent to Numerous	Few/Absent	Absent	Absent
Group C	Few	Common to Numerous *Baetis rhodani* often Abundant Others: never Excessive	Common to Excessive (usually Dominant or Excessive)	Dominant to Excessive	Few or Absent	Absent
Group D	Few or Absent	Few or Absent	Few/Absent to Common	Few/Absent to Common	Dominant to Excessive	Few or Absent
Group E	Few or Absent	Few or Absent	Few or Absent	Few or Absent	Few / Absent to Common	Dominant
Additional Qualifying Criteria						
Cladophora spp. Abundance	Trace only or None	Moderate growths (if present)	May be Abundant to Excessive growths	May be Excessive growths	Few or Absent	None
Macrophytes (Typical abundance)	Normal growths or absent	Enhanced growths	May be Luxuriant growths	May be Excessive growths	Absent to Abundant	Present/Absent
Slime Growths (Sewage Fungus)	Never	Never	Trace or None	May be Abundant	May be Abundant	None
Dissolved Oxygen Saturation	Close to 100% at all times	80% - 120%	Fluctuates from < 80% to >120%	Very unstable. Potential fish-kills	Low (but > 20%)	Very low, sometimes zero
Substratum Siltation	None	May be light	May be light	May be considerable	Usually heavy	Usually very heavy and anaerobic

Note occurrence/abundance of groups in above table refers to some but not necessarily all of the constituents of the group. The Additional Qualifying Criteria apply in virtually all circumstances. Single specimens may be ignored. Seasonal and other relevant factors (i.e., drought, floods) must be taken into account.

* Macroinvertebrate criteria do not apply to rivers with mud, bedrock or sand substrata, very sluggish or torrential flow, head-water or high altitude streams and those affected by significant ground water input, excessive calcification, drainage, canalisation, culverting, marked shading etc.

** See Further Observations overleaf.

Appendix A cont.: Abundance categories and interpretation of macroinvertebrate survey results.

Macroinvertebrates grouped according to their sensitivity to organic pollution

TAXA	Group A	Group B	Group C	Group D	Group E
	Sensitive	*Less Sensitive*	*Tolerant*	*Very Tolerant*	*Most Tolerant*
Plecoptera	All except *Leuctra* spp.	*Leuctra* spp.			
Ephemeroptera	Heptageniidae Siphlonuriidae *Ephemera danica*	Baetidae (excl. *Baetis rhodani*) Leptophlebidae	*Baetis rhodani* Caenidae Ephemerellidae		
Trichoptera		Cased spp.	Uncased spp.		
Odonata		All taxa			
Megaloptera				Sialidae	
Hemiptera		***Aphelocheirus aestivalis***	All except *A. aestivalis*		
Coleoptera			Coleoptera		
Diptera			Chironomidae (excl. *Chironomus* spp.) Simuliidae Tipulidae		*Chironomus* spp. *Eristalis* sp.
Hydracarina			Hydracarina		
Crustacea			*Gammarus* spp. *Austropotamobius pallipes*	*Asellus* spp. *Crangonyx* spp.	
Gastropoda			Gastropoda (excl. *Lymnaea peregra* & *Physa* sp.)	*Lymnaea peregra* *Physa* sp.	
Lamellibranchiata	*Margaritifera margaritifera*		*Anodonta* spp.	Sphaeriidae	
Hirudinea			*Piscicola* sp.	All except *Piscicola* sp.	
Oligochaeta					Tubificidae
Platyhelminthes			All		

Table 3 Abundance categories and relationship to percentage frequency of occurrence (After McGarrigle *et al*., 2002).

Abundance Category	Approx. percentage frequency of occurrence
Absent	no specimens
Present	1 or 2 individuals
Scarce/few	<1% of the total fauna
Small numbers	<5%
Fair Numbers	5-10%
Common	10-20%
Numerous	25 -50%
Dominant	50 -75%
Excessive	>75%

Table 4 Interpretation of quality ratings (After McGarrigle *et al.,* 2002).

Quality ratings	Pollution status
Q5, Q4-5 and Q4	Unpolluted
Q3-4,	Slightly polluted
Q3 and Q2-3	Moderately polluted
Q2, Q1-2 and Q1	Serious pollution

APPENDIX B: BMWP (Biological Monitoring Working Party) Score (after Armitage *et al.*, 1983).

Families	Score
Siphlonuridae, Heptageniidae, Ephemerellidae, Leptophlebiidae, Potamanthidae, Ephemeridae, Taeniopterygidae, Leuctridae, Capniidae, Perlididae, Chloroplidae, Aphelocheiridae, Phyrganidae, Molannidae, Beraeidae, Odontoceridae, Leptoceridae, Goeridae, Lepidostomatidae, Brachycentridae, Sericostomatidae, Perlodidae	10
Astacidae, Lestidae, Agriidae, Gomphidae, Cordulegarsteridae, Aeshnidae, Cordulliidae, Libellulidae, Psychomyidae, Philopotamidae	8
Caenidae, Nemouridae, Rhyacophilidae, Polycentropodidae, Limnephilidae	7
Neritidae, Viviparidae, Ancylidae, Hydroptilidae, Unionidae, Corophidae, Gammaridae, Platycnemididae, Coenagriidae	6
Mesovelidae, Hydrometridae, Gerridae, Nepidae, Naurcoridae, Notonectidae, Pleidae, Corixidae, Halipildae, Hygrobiidae, Dytiscidae, Gyrinidae, Hydrophilidae Clambeidae, Helodidae, Dryopidae, Elmidae, Chrysomelidae, Curculonidae, Hydropschyidae, Tipulidae, Simuliidae, Planariidae, Dendrocoelidae	5
Baetidae, Sialidae, Piscicolidae	4
Valvatidae, Hydrobiidae, Lymnaeidae, Physidae, Planorbidae, Sphaeridae, Glossophoniidae, Hirudinidae, Eropbellidae, Asellidae	3
Chironomidae	2
Oligochaeta	1

Appendix A13.4 EPA Hydrotool Report for the Morell River

Estimation of Flow Duration Curve for Ungauged Catchment

River Name	Morell(09_1558)
XY Location	291648,222149 (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.

Estimation of Flow Duration Curve for Ungauged Catchment

Disclaimer

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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 km^2);
- 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.

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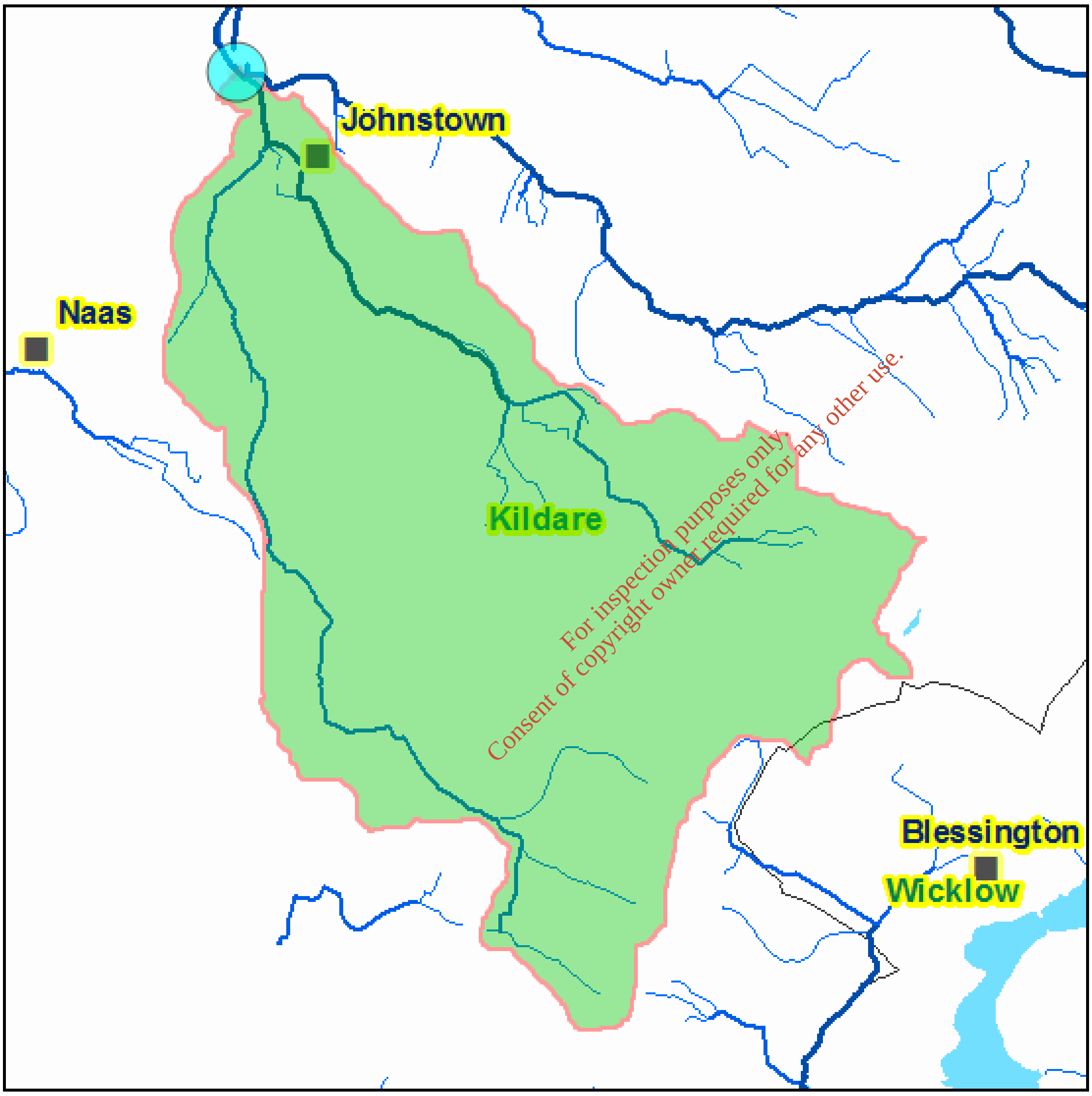
Estimation of Flow Duration Curve for Ungauged Catchment

River Name	Morell(09_1558)
XY Location	291648,222149 (ING)

Nested Catchment Map



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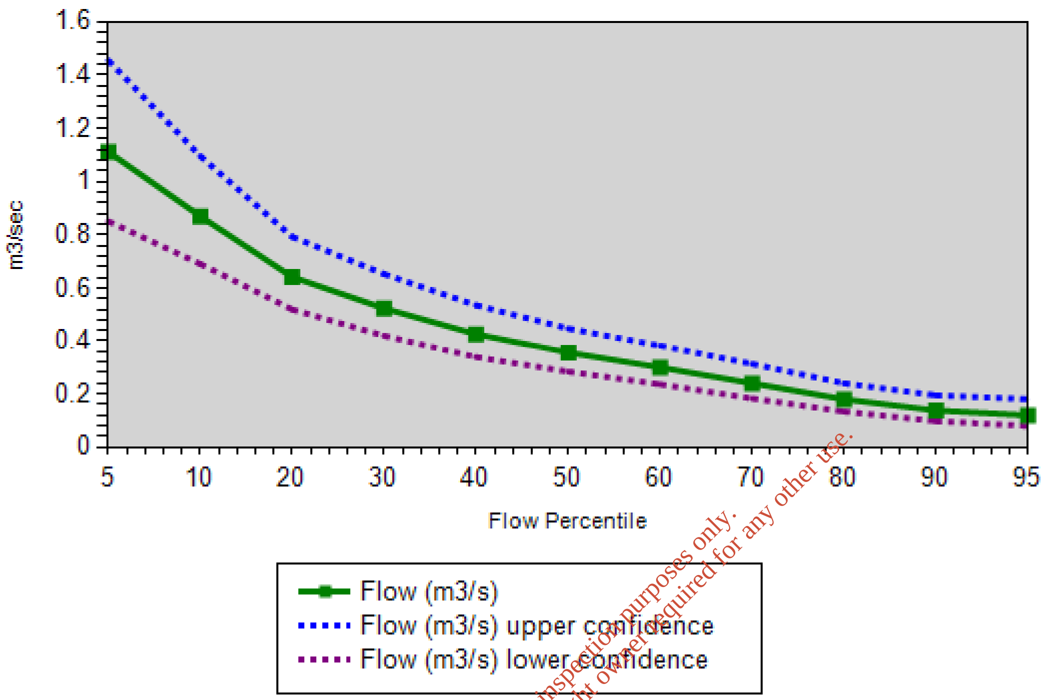
Environmental Protection Agency

Estimation of Flow Duration Curve for Ungauged Catchment

Flow Duration Curve (Flow in m3/sec)



%ile	flow(m3/sec)	upper 95% confidence limit m3/sec	lower 95% confidence limit m3/sec
5	1.111	1.454	0.85
10	0.869	1.095	0.69
20	0.641	0.792	0.519
30	0.523	0.652	0.42
40	0.426	0.535	0.339
50	0.356	0.447	0.284
60	0.3	0.382	0.236
70	0.24	0.313	0.183
80	0.18	0.24	0.134
90	0.138	0.195	0.098
95	0.12	0.18	0.08

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Estimation of Flow Duration Curve for Ungauged Catchment

Catchment Descriptors		
General		
Descriptor	**Unit**	**Value**
Area	sq km	28.3
Average Annual Rainfall (61-90)	mm/yr	956
Stream Length	km	28.7
Drainage Density	Channel length (km)/catchment area (sqkm)	1
Slope	Percent Slope	5.5
FARL	Index (range 0:1)	1

Soil	
Code	**% of Catchment**
Poorly Drained	21.4
Well Drained	75.1
Alluvmin	2.5
Peat	0
Water	0
Made	1

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Estimation of Flow Duration Curve for Ungauged Catchment

Subsoil Permeability		
Code	**Explanation**	**% of Catchment**
H	High	37
M	Moderate	25.5
L	Low	18.5
ML	Moderate/Low	0
NA	No Subsoil/Bare Rock	19

Aquifer		
Code	**Explanation**	**% of Catchment**
LG_RG	LG:Locally important sand-gravel aquifer RG: Regionally important sand-gravel aquifer	16.2
LL	Locally important aquifer which is moderately productive only in local zones	14.5
LM_RF	LM: Locally important aquifer which is generally moderately productive RF: Regionally important fissured bedrock aquifer	0
PU_PL	PU: Poor aquifer which is generally unproductive PL: Poor aquifer which is generally unproductive except for local zones	69.3
RKC_RK	Regionally important karstified aquifer dominated by conduit flow	0
RKD_LK	Regionally important karstified aquifer dominated by diffuse flow	0

Stations in Pooling group			
%ile Flow	**Station 1**	**Station 2**	**Station 3**
5	10038	14104	14057
10	10038	14104	14057
20	10038	14104	14057
30	10038	14104	14057
40	10038	14104	14057
50	10038	14104	14057
60	10038	14104	14057
70	10038	14104	14057
80	10038	14104	14057

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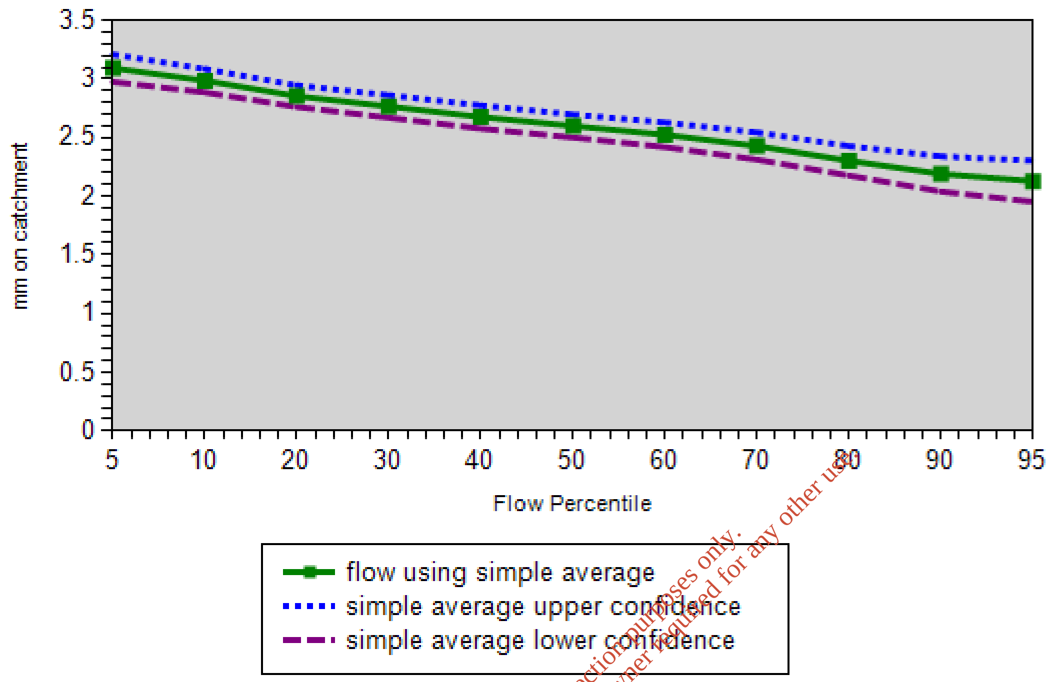
90	10038	14104	14057
95	10038	14104	14057

Estimation of Flow Duration Curve for Ungauged Catchment

Flow Duration Curve (mm on catchment)



Log Flow (mm on catchment)			
%ile	mm	upper 95% confidence limit	lower 95% confidence limit
5	3.093	3.21	2.976
10	2.986	3.086	2.886
20	2.854	2.946	2.762
30	2.766	2.862	2.67
40	2.676	2.775	2.577
50	2.599	2.697	2.501
60	2.524	2.629	2.419
70	2.428	2.544	2.312
80	2.302	2.428	2.176
90	2.19	2.34	2.04
95	2.128	2.304	1.952

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