

UCL ENVIRONMENTAL CHANGE RESEARCH CENTRE



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**River Clyde Environmental Change Network Diatom Analysis Project**

**Final Report to SEPA**

**ECRC Research Report #187**

**E. M. Shilland, G. Clarke & S. Goodrich**

**2017**

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Cover photo: River Clyde Tidal Weir.

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## 4 Introduction

This report provides details of work performed on the SEPA contract to ENSIS Ltd. involving the preparation and analysis of historic (September 1994 – August 2010) Environmental Change Network diatom samples from the River Clyde at the Tidal Weir.

Diatoms were collected from the site by SEPA, forwarded to ENSIS Ltd and prepared for analysis following protocols described in the United Kingdom Environmental Change Network's "Protocols for Standard Measurements at Freshwater Sites" (Sykes *et al.*, 1999). Samples were taken at the site at various times of year and a full list of those that have been received by ENSIS is provided in Appendix 1. For this project, in order to minimise any inter-seasonal variability in the time-series, Kate Arnold from SEPA selected a subset of 16 summer samples for analysis, all collected between late July and early September.

Approximately 400 diatom valves were counted per sample by Gina Clarke using a light microscope with phase contrast at 1000x magnification. Count data were recorded on a spreadsheet and transferred to ENSIS where they have been added to the ECN diatom database and have also been provided to SEPA.

The diatom count data was run through the DARLEQII program (Kelly *et al.*, 2011) in order to generate Trophic Diatom Index (TDI), Ecological Quality Ratio (EQR) and status class values (high, good, moderate, poor, bad) for each sample. Alkalinity values for the calculations were provided by SEPA for all samples except the earliest three in the time-series, for which the average from all samples was used. Both TDI3 and TDI4 scores were calculated for all samples and the scores reported here. Table 1 is taken from the DARLEQII user guide (Kelly *et al.*, 2011) and describes the output fields provided in the results section for the site below. Electronic copies of the full DARLEQII program output have been provided to SEPA.

**Table 1 Trophic Diatom Index (TDI) calculation output field descriptions**

<b>Field name</b>	<b>Field description</b>
Sample sum	Sum of the counts or percentages of all taxa in a sample
Sum TDI3/4	Sum of the counts or percentages for all taxa in a sample that are matched to taxa in the master taxon list and included in the TDI calculation. If all taxa are matched this will be the same as the Sample sum. Comparison of these two fields will indicate if there are important taxa present in the sample but not included in the status calculations
TDI3/4	TDI score for each sample using the revised TDI taxon scores for rivers.
eTDI3/4	Expected TDI score for each sample according to site-specific prediction (rivers)
EQR TDI3/4	Ecological Quality Ratio for each sample based on predicted TDI for observed alkalinity and season (rivers).
Class	Status class based on EQR
% Planktic	Percentage of planktic diatoms in the sample. These are excluded from the status calculations
% Motile	Percentage of the motile diatoms in the sample
%OrganicTolerant	Percentage of organic pollution tolerant diatoms in the sample
%Saline	Percentage of diatoms tolerant of slightly saline waters
Comments	List of any warning messages generated during calculations for individual samples.

## 5 Site R13. Lower Clyde



**Figure 1 River Clyde. Looking south-east from the bridge on the A8. Image from Google Streetview**

### 5.1 Site Description

“The catchment area of the River Clyde is about 2000km<sup>2</sup> and the river changes in character a great deal in its 121km journey to the tidal weir in Glasgow. In its upper reaches, it is used to fill the Daer reservoir which supplies drinking water to much of South Lanarkshire; there is also sheep farming and commercial afforestation in this part of the catchment. The river is joined by tributaries of various sizes and quality reflecting the land uses of their catchments: there is much opencast coal mining in some, whilst others are urban or agricultural. The Clyde passes through a fertile valley in its middle reaches where there is extensive market gardening, fruit growing and garden centres. In its lower reaches the river receives a considerable amount of treated sewage effluent from large regional sewage works. The river is quite sluggish in its flow because of the flat landscape. As a result of this and the BOD of the effluents, there is serious oxygen depletion in the lower reaches during the summer months.

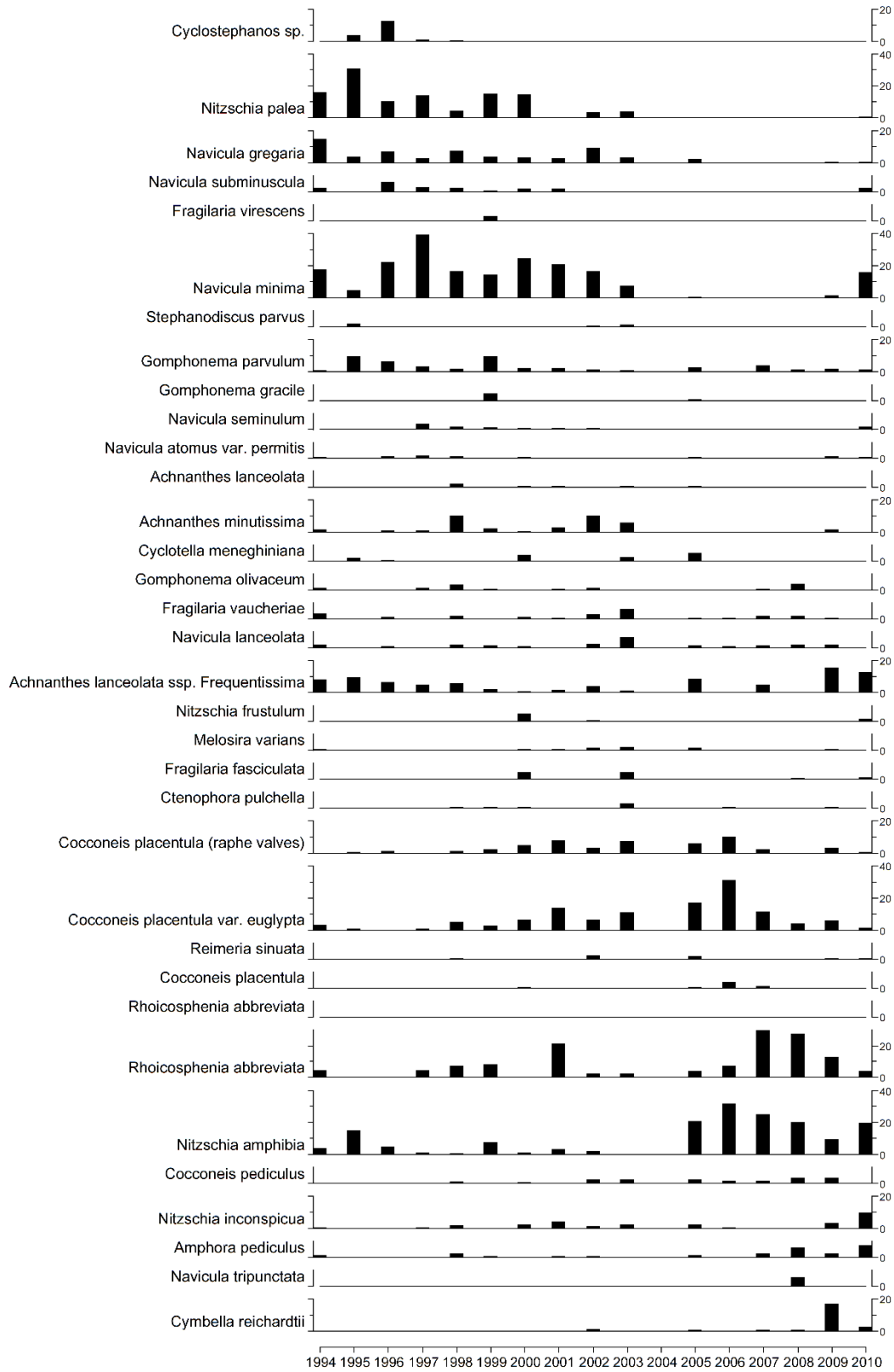
The ECN sampling site is situated in the lowest reach, where average flow is 41 cumecs.” ([ECN website](#), 2017).

## 5.2 Diatom Count Summary

16 ECN diatom samples from the location S01 in the River Clyde (Table 2.) were either retrieved from the UCL archive or prepared into diatom slides and counted using standard methods (Battarbee *et al.* 2001). A percentage abundance time-series plot of diatom species was generated using the program C2 (Juggins, 2007), and is shown in Figure 2. It includes all species occurring at abundances greater than two percent. Diatom species recorded and the number of samples in which they occurred are presented in Table 3. and Figure 3. Trophic Diatom Index (TDI) scores (Kelly *et al.*, 2008) were calculated for each sample. TDI3 scores are provided in Table 4. and TDI4 scores in Table 5. No samples were collected in 2004.

**Table 2 River Clyde. Diatom samples analysed.**

Sample Code	Sample Date	Season	ECN Sample Number
CLYDE001	05/09/1994	3	S01
CLYDE004	17/08/1995	2	S01
CLYDE007	31/07/1996	2	S01
CLYDE010	23/07/1997	2	S01
CLYDE013	28/07/1998	2	S01
CLYDE017	04/08/1999	2	S01
CLYDE018	08/08/2000	2	S01
CLYDE021	23/08/2001	2	S01
CLYDE016	29/08/2002	2	S01
CLYDE022	29/08/2003	2	S01
CLYDE023	23/08/2005	2	S01
CLYDE024	30/08/2006	2	S01
CLYDE025	30/08/2007	2	S01
CLYDE026	29/08/2008	2	S01
CLYDE027	27/08/2009	2	S01
CLYDE028	19/08/2010	2	S01



**Figure 2 River Clyde. Diatom Percentage Summary Abundances**



**Table 3 River Clyde. Diatom species and number of occurrences.**

Taxon	Taxon Code	Number of Occurrences (nmax = 16)
<i>Achnanthes lanceolata</i> ssp. <i>Frequentissima</i>	AC001R	16
<i>Achnanthes minutissima</i>	AC013A	16
<i>Cocconeis placentula</i> (raphe valves)	CO001Z	16
<i>Cocconeis placentula</i> var. <i>euglypta</i>	CO001B	16
<i>Gomphonema parvulum</i>	GO013A	16
<i>Navicula gregaria</i>	NA023A	16
<i>Navicula minima</i>	NA042A	16
<i>Nitzschia amphibia</i>	NI014A	16
<i>Fragilaria fasciculata</i>	FR057A	15
<i>Navicula lanceolata</i>	NA009A	15
<i>Cocconeis pediculus</i>	CO005A	14
<i>Fragilaria vaucheriae</i>	FR007A	14
<i>Nitzschia inconspicua</i>	NI043A	14
<i>Nitzschia palea</i>	NI009A	14
<i>Rhoicosphenia abbreviata</i>	RC002A	14
<i>Cymbella silesiaca</i>	CM103A	13
<i>Melosira varians</i>	ME015A	13
<i>Amphora pediculus</i>	AM012A	12
<i>Cocconeis placentula</i>	CO001A	12
<i>Ctenophora pulchella</i>	YH001A	12
<i>Cymbella reichardtii</i>	CM113A	12
<i>Gomphonema olivaceum</i>	GO001A	12
<i>Nitzschia frustulum</i>	NI008A	12
<i>Synedra ulna</i>	SY001A	12
<i>Achnanthes lanceolata</i>	AC001A	11
<i>Navicula atomus</i> var. <i>permitis</i>	NA084B	11
<i>Cyclotella meneghiniana</i>	CY003A	10
<i>Navicula subminuscula</i>	NA134A	10
<i>Navicula seminulum</i>	NA005A	9
<i>Reimeria sinuata</i>	RE001A	9
<i>Diatoma vulgare</i>	DT003A	8
<i>Gomphonema augur</i>	GO019A	8
<i>Achnanthes clevei</i>	AC006A	7
<i>Achnanthes laterostrata</i>	AC018A	7
<i>Achnanthes lauenbergiana</i>	AC085A	7
<i>Gomphonema gracile</i>	GO004A	7

Taxon	Taxon Code	Number of Occurrences (nmax = 16)
<i>Cymbella minuta</i>	CM031A	6
<i>Fragilaria pinnata</i>	FR001A	6
<i>Navicula cryptotenella</i>	NA751A	6
<i>Nitzschia capitellata</i>	NI028A	6
<i>Nitzschia dissipata</i>	NI015A	6
<i>Stephanodiscus parvus</i>	ST010A	6
<i>Navicula subrotundata</i>	NA114A	5
<i>Surirella brebisonii</i> var. <i>kuetzingii</i>	SU073B	5
<i>Cocconeis placentula</i> var. <i>lineata</i>	CO001C	4
<i>Cyclostephanos</i> sp.	CC9999	4
<i>Fragilaria capucina</i>	FR009A	4
<i>Gomphonema</i> sp.	GO9999	4
<i>Gomphonema truncatum</i>	GO023A	4
<i>Navicula capitata</i>	NA066A	4
<i>Navicula pseudokotschyi</i>	NAZZZZ	4
<i>Navicula tripunctata</i>	NA095A	4
<i>Nitzschia fonticola</i>	NI002A	4
<i>Achnanthes conspicua</i>	AC023A	3
<i>Diatoma tenue</i>	DT004A	3
<i>Fragilaria capucina</i> var. <i>gracilis</i>	FR009H	3
<i>Fragilaria leptostauron</i>	FR014A	3
<i>Gomphonema angustatum</i> agg.	GO003A	3
<i>Meridion circulare</i>	MR001A	3
<i>Achnanthes linearis</i>	AC002A	2
<i>Caloneis bacillum</i>	CA002A	2
<i>Cyclostephanos tholiformis</i>	CC003A	2
<i>Gyrosigma</i> sp.	GY9999	2
<i>Navicula cryptocephala</i>	NA007A	2
<i>Navicula pseudoventralis</i>	NA590A	2
<i>Navicula radiosa</i> var. <i>tenella</i>	NA003B	2
<i>Nitzschia acicularis</i>	NI042A	2
<i>Nitzschia linearis</i>	NI031A	2
<i>Pinnularia microstauron</i>	PI011A	2
<i>Pinnularia</i> sp.	PI9999	2
<i>Stephanodiscus hantzschii</i>	ST001A	2
<i>Tabellaria flocculosa</i>	TA001A	2
<i>Achnanthes altaica</i>	AC046A	1
<i>Achnanthes marginulata</i>	AC022A	1
<i>Amphora libyca</i>	AM011A	1
<i>Amphora ovalis</i>	AM001A	1

<b>Taxon</b>	<b>Taxon Code</b>	<b>Number of Occurrences (nmax = 16)</b>
Asterionella formosa	AS001A	1
Aulacoseira sp.	AU9999	1
Brachysira vitrea	BR001A	1
Cyclostephanos dubius	CC001A	1
Cymbella affinis	CM022A	1
Cymbella microcephala	CM004A	1
Diatoma mesodon	DT021A	1
Eunotia implicata	EU107A	1
Eunotia microcephala	EU028A	1
Eunotia pectinalis	EU002A	1
Eunotia sp.	EU9999	1
Fragilaria capucina var. perminuta	FR009J	1
Fragilaria construens var. venter	FR002C	1
Fragilaria virescens	FR005A	1
Frustulia rhomboides var. saxonica	FU002B	1
Frustulia vulgaris	FU001A	1
Gomphonema pumilum	GO080A	1
Gyrosigma acuminatum	GY005A	1
Hannaea arcus	HN001A	1
Meridion circulare var. constrictum	MR001B	1
Navicula jaernefeltii	NA002A	1
Navicula lenzii	NA761A	1
Navicula mediocris	NA006A	1
Navicula mutica	NA025A	1
Navicula protracta	NA047A	1
Navicula pupula	NA014A	1
Navicula saprophila	NA617A	1
Navicula sp.	NA9999	1
Nitzschia gracilis	NI017A	1
Nitzschia hungarica	NI007A	1
Nitzschia sp.	NI9999	1
Pinnularia viridis	PI007A	1
Surirella minuta	SU016A	1
Synedra acus	SY003A	1
Tetracyclus emarginatus	TE003A	1

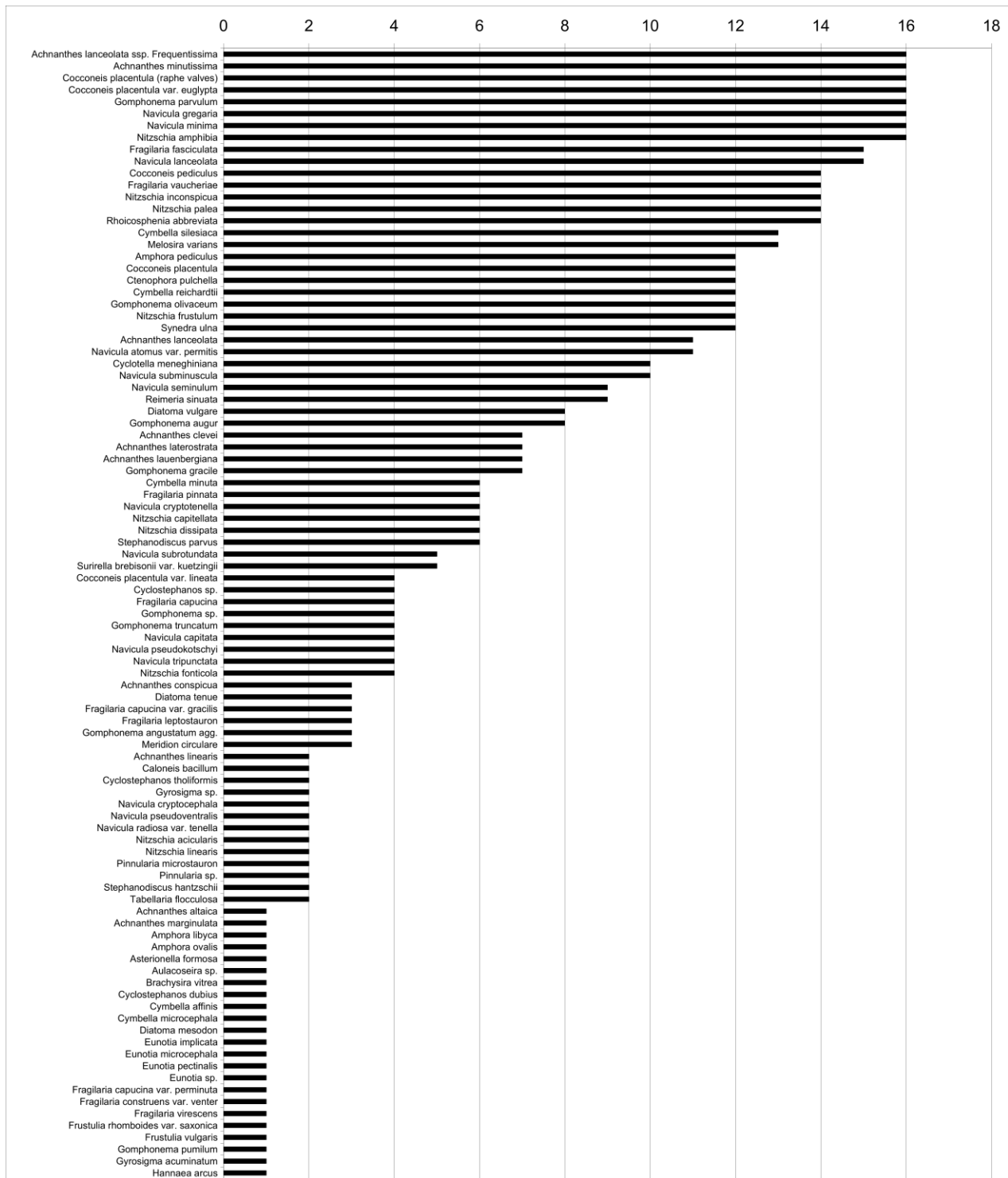


Figure 3 River Clyde. Diatom species and number of occurrences.

**Table 4 River Clyde. Trophic Diatom Index TDI3 Scores**

SampleDate	ECRC_SampleID	Alkalinity	ECN_SITEID	Sample sum	Sum TDI3	TDI3	eTDI3	EQR TDI3	Class TDI3	% Planktic	% Motile	% Organic tolerant	% Saline
05/09/1994	CLYD001	83.2	R13	435	433	64.492	39.189	0.584	Moderate	0.46	63.91	57.70	1.38
17/08/1995	CLYD004	83.2	R13	342	311	71.463	39.189	0.469	Poor	8.48	64.04	54.97	1.46
31/07/1996	CLYD007	83.2	R13	434	373	63.539	39.189	0.600	Moderate	14.06	60.60	57.83	1.84
23/07/1997	CLYD010	91	R13	438	429	60.839	39.444	0.647	Moderate	2.05	72.60	66.89	2.74
28/07/1998	CLYD013	81	R13	471	464	58.675	39.105	0.679	Moderate	1.27	43.31	39.28	3.61
04/08/1999	CLYD017	84	R13	421	420	61.905	39.218	0.627	Moderate	0.24	52.26	50.36	3.33
08/08/2000	CLYD018	77	R13	418	395	63.228	38.937	0.602	Moderate	5.02	61.24	59.09	13.40
23/08/2001	CLYD021	78	R13	485	480	66.615	38.981	0.547	Moderate	0.82	38.76	34.23	4.74
29/08/2002	CLYD016	76	R13	409	400	59.000	38.891	0.671	Moderate	1.22	45.97	37.41	5.87
29/08/2003	CLYD022	95	R13	417	388	58.698	39.552	0.683	Moderate	4.56	30.94	27.58	11.99
23/08/2005	CLYD023	89	R13	474	450	73.500	39.384	0.437	Poor	5.06	35.02	12.03	4.64
30/06/2006	CLYD024	86	R13	428	428	78.797	36.078	0.332	Poor	0.00	37.15	3.74	3.04
30/08/2007	CLYD025	88	R13	416	414	76.329	39.353	0.390	Poor	0.24	29.33	6.97	1.92
29/08/2008	CLYD026	77	R13	445	442	77.885	38.937	0.362	Poor	0.45	35.73	4.94	2.25
27/08/2009	CLYD027	79	R13	469	469	65.672	39.023	0.563	Moderate	0.00	22.39	11.73	5.33
19/08/2010	CLYD028	81	R13	469	469	71.908	39.105	0.461	Poor	0.00	56.93	35.39	14.07

**Table 5 River Clyde. Trophic Diatom Index TDI4 Scores**

SampleDate	ECRC_SampleID	Alkalinity	ECN_SITEID	Sample sum	Sum TDI4	TDI4	eTDI4	EQR TDI4	Class TDI4	% Planktic	% Motile	% Organic tolerant	% Saline
05/09/1994	CLYD001	83.2	R13	435	433	63.447	47.048	0.552	Moderate	0.46	63.91	57.70	1.38
17/08/1995	CLYD004	83.2	R13	342	311	70.844	47.048	0.440	Moderate	8.48	64.04	54.97	1.46
31/07/1996	CLYD007	83.2	R13	434	373	62.895	47.048	0.561	Moderate	14.06	60.60	57.83	1.84
23/07/1997	CLYD010	91	R13	438	429	60.280	48.554	0.618	Good	2.05	72.60	66.89	2.74
28/07/1998	CLYD013	81	R13	471	464	57.037	46.606	0.644	Good	1.27	43.31	39.28	3.61
04/08/1999	CLYD017	84	R13	421	420	61.071	47.206	0.590	Moderate	0.24	52.26	50.36	3.33
08/08/2000	CLYD018	77	R13	418	395	60.481	45.783	0.583	Moderate	5.02	61.24	59.09	13.40
23/08/2001	CLYD021	78	R13	485	480	61.422	45.992	0.571	Moderate	0.82	38.76	34.23	4.74
29/08/2002	CLYD016	76	R13	409	402	56.213	45.573	0.644	Good	1.22	45.97	37.41	5.87
29/08/2003	CLYD022	95	R13	417	388	53.937	49.295	0.727	Good	4.56	30.94	27.58	11.99
23/08/2005	CLYD023	89	R13	474	450	68.028	48.176	0.494	Moderate	5.06	35.02	12.03	4.64
30/06/2006	CLYD024	86	R13	428	428	70.485	47.599	0.451	Moderate	0.00	37.15	3.74	3.04
30/08/2007	CLYD025	88	R13	416	414	73.285	47.985	0.411	Moderate	0.24	29.33	6.97	1.92
29/08/2008	CLYD026	77	R13	445	442	76.550	45.783	0.346	Poor	0.45	35.73	4.94	2.25
27/08/2009	CLYD027	79	R13	469	469	61.834	46.198	0.568	Moderate	0.00	22.39	11.73	5.33
19/08/2010	CLYD028	81	R13	469	469	71.098	46.606	0.433	Moderate	0.00	56.93	35.39	14.07

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## 7 Appendices

### Appendix 1. All River Clyde Diatom Samples

ECRC sample name	Sampling date	Season	ECN_samp_no	ECN site number
CLYD001	05/09/1994	3	S01	R13
CLYD002	05/09/1994	3	S02	R13
CLYD003	05/09/1994	3	S03	R13
CLYD004	17/08/1995	2	S01	R13
CLYD005	17/08/1995	2	S02	R13
CLYD006	17/08/1995	2	S03	R13
CLYD007	31/07/1996	2	S01	R13
CLYD008	31/07/1996	2	S02	R13
CLYD009	31/07/1996	2	S03	R13
CLYD010	23/07/1997	2	S01	R13
CLYD011	23/07/1997	2	S02	R13
CLYD012	23/07/1997	2	S03	R13
CLYD013	28/07/1998	2	S01	R13
CLYD014	28/07/1998	2	S02	R13
CLYD015	28/07/1998	2	S03	R13
CLYD016	29/08/2002	2	S01	R13
CLYD017	04/08/1999	2	S01	R13
CLYD018	08/08/2000	2	S01	R13
CLYD019	08/08/2000	2	S02	R13
CLYD020	08/08/2000	2	S03	R13
CLYD021	23/08/2001	2	S01	R13
CLYD022	29/08/2003	2	S01	R13
CLYD023	23/08/2005	2	S01	R13
CLYD024	30/08/2006	2	S01	R13
CLYD025	30/08/2007	2	S01	R13
CLYD026	29/08/2008	2	S01	R13
CLYD027	27/08/2009	2	S01	R13
CLYD028	19/08/2010	2	S01	R13
CLYD029	16/04/2014	1	S01	R13
CLYD030	16/04/2014	1	S02	R13
CLYD031	16/04/2014	1	S03	R13
CLYD032	17/11/2014	3	S01	R13
CLYD033	15/05/2015	1	S01	R13
CLYD034	02/10/2015	3	S01	R13