Tales of the Riverbank

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2002

Appendix A: Student Handouts

Tales of the Riverbank

Midshire River Authority has received a complaint about a perceived reduction in number and size of fish caught along the Coley River.

As investigating officers, your task is to identify the possible causes and suggest any remedy if required.

Tales of the Riverbank

SCIENTIFIC SKILLS

- environmental issues
- pollution
- water quality
- sampling
- analytical techniques
- data analysis / interpretation
- ecotoxicity
- remediation

TRANSFERABLE SKILLS

- working with others
- communication
- decision making
- analytical/critical thinking
- independent learning
- time management

What you need to do

Decide

- Whether there is a problem
- Where and when did it occurred
- The nature of the pollution
- The potential sources of pollution
- Whether there are toxicological issues
- Who could be at fault
- How the problem can be remedied

Beauport Angling Association,
12, The Sea View,
Beauport,
Midshire.

Colin Brookes
Chairman of Midshire River Authority,
1-20 The Rise,
Beauport,
Midshire.

12/8/02

Dear Colin,

As we discussed yesterday, over the last few years there has been a reduction in the number and size of fish caught in the competition that is held between Atwood and Coley Bridge. This has caused a great deal of concern among my members. I hope you will remedy this as soon as possible.

The increased industrialisation and urbanisation around the river is also a concern as is the doubling of the cost of fishing permits and the reduction of access.

Yours sincerely,

A. Pickles

Arthur Pickles
President of the Beauport Angling Association

Consider what a drop in numbers of fish could signify.

NOTES

The River Coley arises from springs in the Limestone hills. The water in the upper reaches is clear. It is not until the tidal reach just below the Coley Bridge at the Coley Weir that the water becomes turbid. The number of fishing licences issued has increased by 10% over the last two decades.

Beauport Angling Association was formed in 1931 and has since then organised monthly competitions on the Coley River during the season. In the 1960s, due to severe river pollution, the competitions could no longer be held below the town of Atwood. It was not until 1984 that trout was once again caught in the Coley. The Coley River has become renowned for trout fishing in the last decade through a programme of annual restocking. In 1997, the first competition for 30 years was held downstream of Atwood.

Mr Arthur Pickles is the president of the Beauport Angling Association, which has shown a small increase in the number of members in recent years. He is also a councillor of Midshire County Council.

Suggest a definition of pollution.

Give one example for each of the following ways of classifying pollution.

1. **Domestic, industrial and agricultural**
2. **Solid, liquid, and gas**
3. **Organic and inorganic**

Midshire River Authority,
1-20 The Rise,
Beauport,
Midshire.

Beauport Angling Association
12 The Sea View
Midshire

Re: Falling Fish Numbers

15/8/02

Dear Mr Pickles

We are currently looking into your complaint. Investigators shall be sent to take samples and look into the possible cause in the perceived drop in fish numbers. From this information, we will determine whether there is a problem requiring further investigation.

As for the second part of your letter, you need to bring this up with the local council and the landowners. If you have further questions do not hesitate to contact me.

Yours sincerely

ML Evison

Michael L. Evison, PhD
Chief Chemist

You are the investigation team reporting to Dr. Evison on the alleged problem reported by Mr Pickles.

Identify the possible causes of pollution and how you would investigate them.

NOTES

There are four automatic monitoring stations on the Coley River run by Midshire River Authority.

1. Upstream of Atwood.
2. Downstream of Atwood.
3. Coley Bridge.
4. Coley Estuary (Between Beauport and the sewage treatment plant.)

The clean up of the Coley River was lead by Midshire River Authority and Beauport County Council. The dumping of untreated industrial waste and sewage has been stopped.

The building of new sewers and Beauport sewage treatment works has meant that no raw sewage should any longer get into the River Coley. This is currently running at 100% capacity.

Each of the small towns has retained their pre-war sewage treatment works that still discharge some treated sewage into the rivers. A new drinking water treatment works at Gottland Water was opened in 1990.

Landuse along the Coley River

Between Coley Bridge and Atwood.

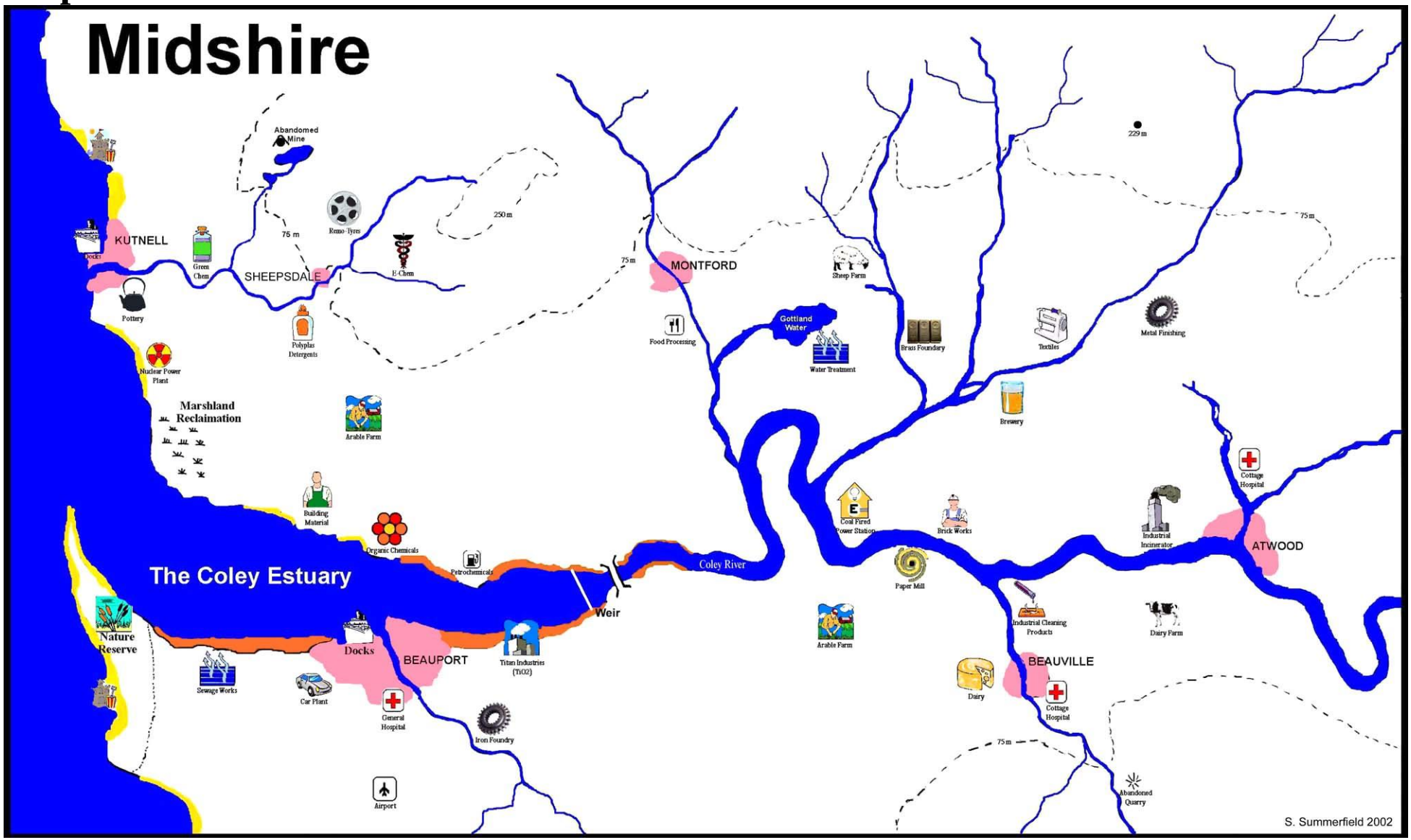
1. Atwood Incinerators Ltd. commissioned their industrial incinerator two years ago. It processes mainly domestic waste. The ash is buried on site.
2. Beauport Beers Ltd. brews Beauport Beer and Three Fishes Lager. They have changed to a three-shift system and have increased its workforce by 30% since January 2000. Their discharge consent is currently under review.
3. Beauville Cottage Hospital is a maternity hospital and has a small incinerator onsite for clinical waste.
4. Brady's Brass Ltd. is a Brass Foundry that was founded in 1889. In August, it was shut for cleaning and repairs.
5. Clay Products Ltd. produces bricks and ceramic tiles for local and international markets. It expects an up-turn in profits and expansion soon.
6. Clover Dairy Ltd. produces milk, cheese & butter.
7. Coley River Power Station is an old coal fired power station owned by Midshire Electricity.
8. Coley Water Company (Gottland Water) is a drinking water extraction and treatment works. Gottland Water was constructed in the 1930s to serve the area for fresh water and is used for water sports during the summer. The new drinking water treatment works was constructed in 1990.
9. Dexter's Farm, three years ago changed his winter feeding of his dairy herd to silage and is hoping to be accredited as being organic this year.
10. Finley's Farm is an Arable Farm of 2000 acres of wheat and corn that has since 1999 changed to organic fertiliser. In recent years there has been a number of complaints over the odour and stomach upsets especially after it has rained.
11. Grant & O'Donald Ltd. is a metal finisher involving cleaning, platting and enamelling of both ferrous and non-ferrous metals. Last month, this company received a large order from Midshire Airport for the refurbishment of the restaurant and seating area. It has long-standing discharge consent with Coley Water Company.
12. Harmony Cleaning Products Ltd. produces industrial cleaning products and a range of hair care products and creams. No discharge consent has so far been applied for.
13. Marples Farm has over 5000 sheep that are kept in the hills north of the Coley Valley
14. McNulties Crisps PLC is a large manufacturer of crisps, biscuits etc. and turnover increased last year by 7%.
15. Paperpak Ltd. produces paper and cardboard from wood pulp by the bisulphite method. It has announced the refurbishment of the plant by the end of the year.
16. Terry's Textiles Ltd. both processes raw wool and produces woollen dyed cloth. Last year a quarter of the staff was laid off. The parent company blamed the loss of orders from a major retail chain and stiff competition from abroad. It has long-standing discharge consent with Coley Water Company.
17. The market town of Beauville has a population of 8000 people and has a secondary water treatment works.
18. Town of Montford has a population of 12000 people and has a secondary water treatment works.

Upstream of Atwood.

1. Atwood Cottage Hospital was built in 1922 and has a small incinerator for clinical waste.
2. Town of Atwood has a population of 25,000 people and has a secondary water treatment works.

Compile a summary of the potential pollution from the various activities along the Coley River.

Map of Midshire



Survey of Land-use

Company	Industry	Potential Pollution	Environmental Effect
a. Atwood Incinerators Ltd.	Waste disposal by incineration		
b. Dexter's Farm	Dairy farm		
c. Brady's Brass Ltd.	Brass foundry		
d. Finley's Farm	Arable farm		

Survey of Land-use

Company	Industry	Potential Pollution	Environmental Effect
e. Beauport Beers Ltd.	Brewery for Lager and Beer		
f. Clover Dairy Ltd.	Dairy products Milk, cheese & butter		
g. McNulties Crisps PLC	Food Processing (crisps and biscuits)		
h. Beauville Cottage Hospital	Hospital (Cottage) Local hospital and incinerator		

Survey of Land-use

Company	Industry	Potential Pollution	Environmental Effect
i. Harmony Cleaning Products Ltd.	Industrial cleaning products, detergents & cosmetics		
j. Clay Products Ltd.	Ceramics / brick works		
k. Paperpak Ltd.	Paper pulp processes to make card and paper		
l. Grant & O'Donald Ltd.	Metal finishing and plating		

Survey of Land-use

Company	Industry	Potential Pollution	Environmental Effect
m. Marples Farm	Sheep farm		
n. Cole Water Authority (Gottland Water)	Drinking Water treatment plant		
o. Cole River Power Station	Coal fired power station		
p. Terry's Textiles Ltd.	Dying and finishing of woollen cloth.		

Monitoring Station Reports

The reports show average monthly data at the four monitoring stations along the Coley River. Note that for the last three years, July and August have been dry so causing low river levels.

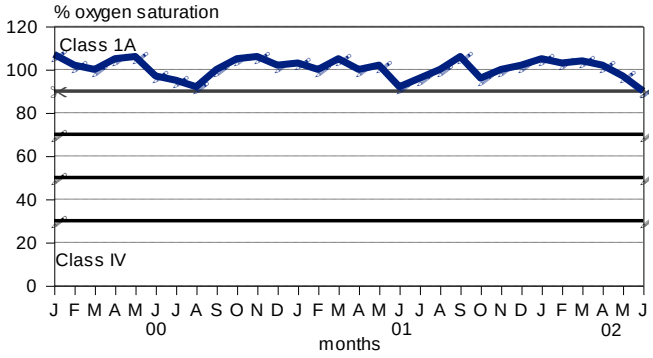
Study the reports and then consider the following:

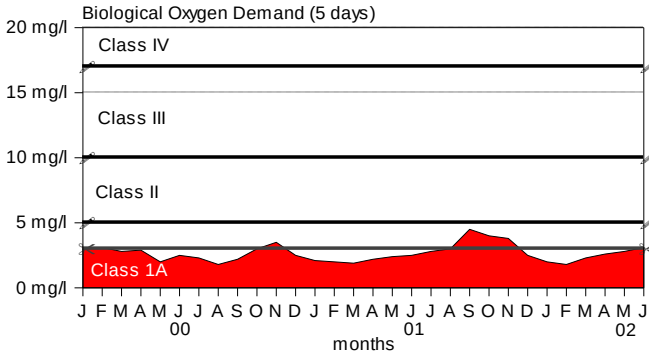
Whether it is an ongoing problem.

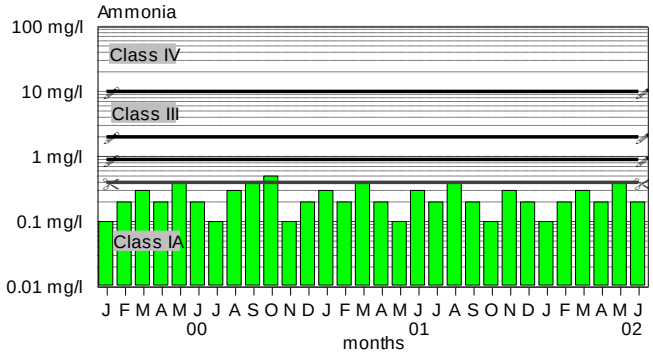
Where on the river the problem occurs.

The potential cause of the problem.

Sampling Point 1
Upstream of Atwood







Notes

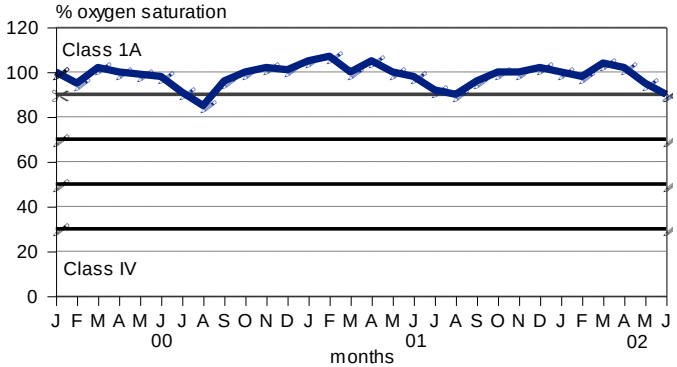
Numerous types of fish, including trout, perch and minnow.

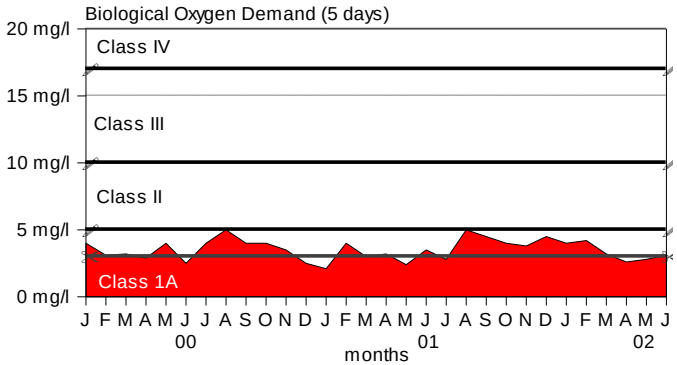
In recent years, this area has again become a spawning ground for salmon. Moderate amount of algae. No silting of the bottom observed.

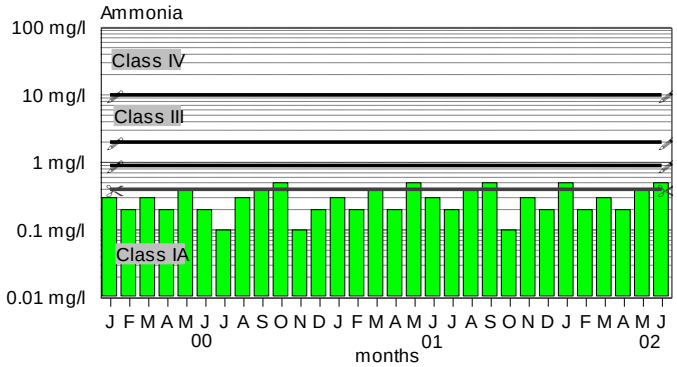
The River Coley is fed by springs and streams originating from the limestone hills and is classed as hard water.

Riverbed is limestone and shale so the water is typically clear with low suspended solids.

Sampling Point 2
Downstream of Atwood





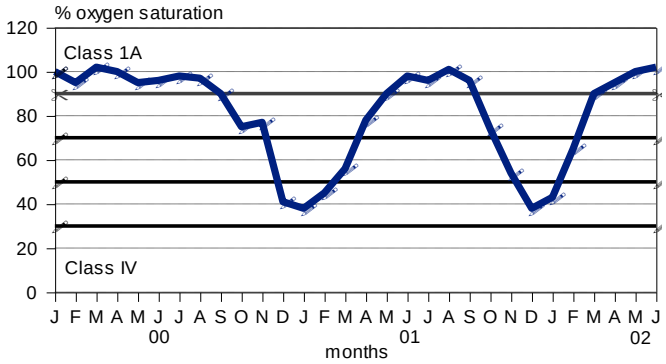


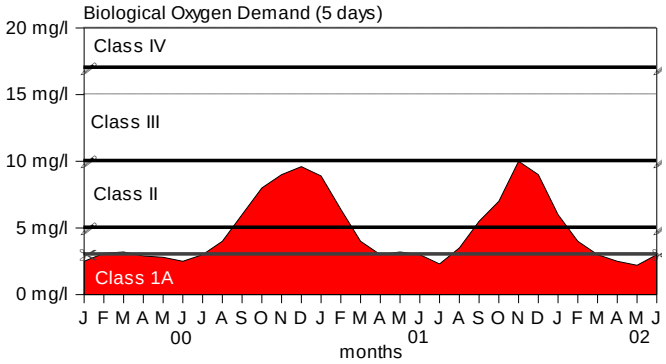
Notes

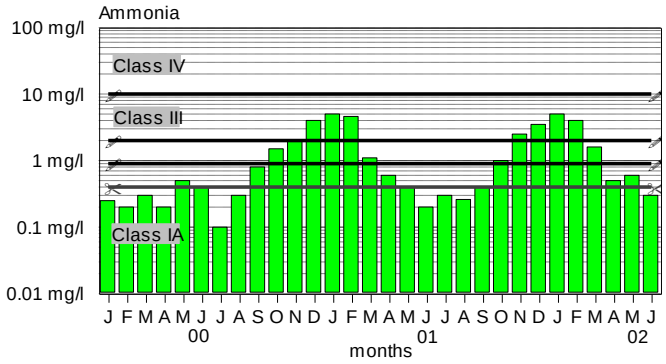
Numerous types of fish, including trout, minnows, and perch. In the last year, roach, pike and chub have also been caught again.

In the last five years, this has become once again a very popular area for angling. Moderate amount of algae. No silting of the bottom observed.

Sampling Point 3
Coley Bridge, Midshire



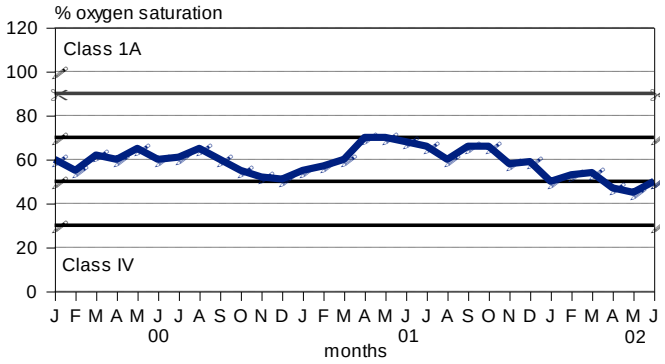


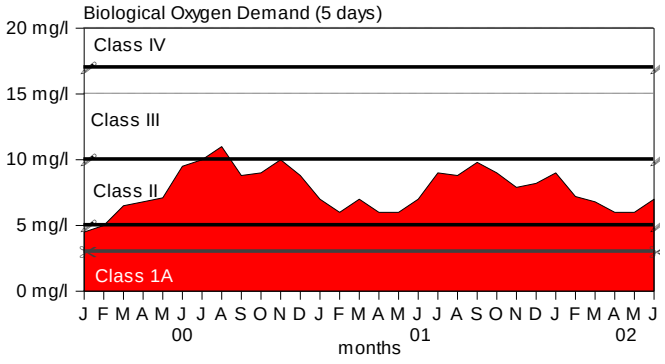


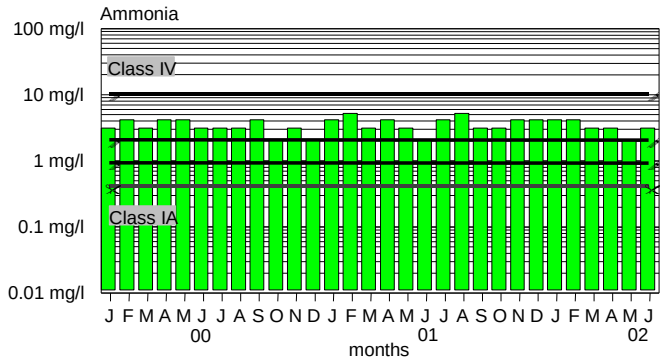
Notes

The moderate amount of algae has increased over the last few years and is especially acute during the Autumn. Silting is evident with a high loading evident.

Sampling Point 4
Beauport (Coley Estuary)







Notes

No observed changes have been observed in this tidal part of the River Coley. The tidal reach is just east of the Coley Bridge at the Coley Weir.

High loading of suspended solids. As the flow decreases deposition on mud and sandbanks occur.

Analytical Request Form A

Request submitted by Investigation Group

……..:

Sample	What are you looking for?	Method of Analysis?
	1.	
	2.	

Analytical Request Form A

Request submitted by Investigation Group

……..:

Sample	What are you looking for?	Method of Analysis?
	1.	
	2.	

Recent Monitoring Station Reports

The averaged monthly data for the period 1 June to 17 August has been collected at the four monitoring stations.

Note: BOD for 17/08/02 will be available next week.

THE TASK

- **Study the results.**
- **Identify the region of the river you wish to sample.**
- **Consider how many samples you would wish to collect and how you would you collect them.**

Point 1	1st June	1st July	1st August	17th August
5 day BOD (mg/l)	3.1	2.9	3.1	not available
COD (mg/l)	5.2	4.1	4.8	5.2
Conductivity (µS/cm)	380	396	400	380
Ammonia (mg/l)	0.2	0.1	0.3	0.2
Dissolved Oxygen (% O_2 saturation)	90	96	89	90
Notes	Sample was clear with low suspended solids and no apparent odour The sampling point is upstream of Atwood.			

Point 3	1st June	1st July	1st August	17th August
5 day BOD (mg/l)	3.0	3.2	5.2	not available
COD (mg/l)	5.1	5.4	8.1	15.4
Conductivity (µS/cm)	450	410	809	1465
Ammonia (mg/l)	0.3	0.6	3.0	8.7
Dissolved Oxygen (% O_2 saturation)	80	82	49	54
Notes	High loading of solids that settled after a few minutes and some white scum on the surface. No apparent odour. Sampling point at Coley Bridge.			

Point 2	1st June	1st July	1st August	17th August
5 day BOD (mg/l)	3.6	3.2	3.4	not available
COD (mg/l)	5.1	5.6	5.4	5.6
Conductivity (µS/cm)	345	450	380	398
Ammonia (mg/l)	0.3	0.5	0.3	0.4
Dissolved Oxygen (% O_2 saturation)	98	92	88	93
Notes	Sample was clear with low suspended solids and no apparent odour The sampling point is just downstream of Atwood.			

Point 4	1st June	1st July	1st August	17th August
5 day BOD (mg/l)	10	8.9	9.9	not available
COD (mg/l)	13.1	13.6	12.8	13.1
Conductivity (µS/cm)	>5000	>5000	>5000	>5000
Ammonia (mg/l)	9.0	8.0	7.5	9
Dissolved Oxygen (% O_2 saturation)	50	54	61	50
Notes	Turbid water that quickly settled. Some oil present on the surface and slightly unpleasant odour. The sampling point is just downstream of Beauport on the Coley Estuary			

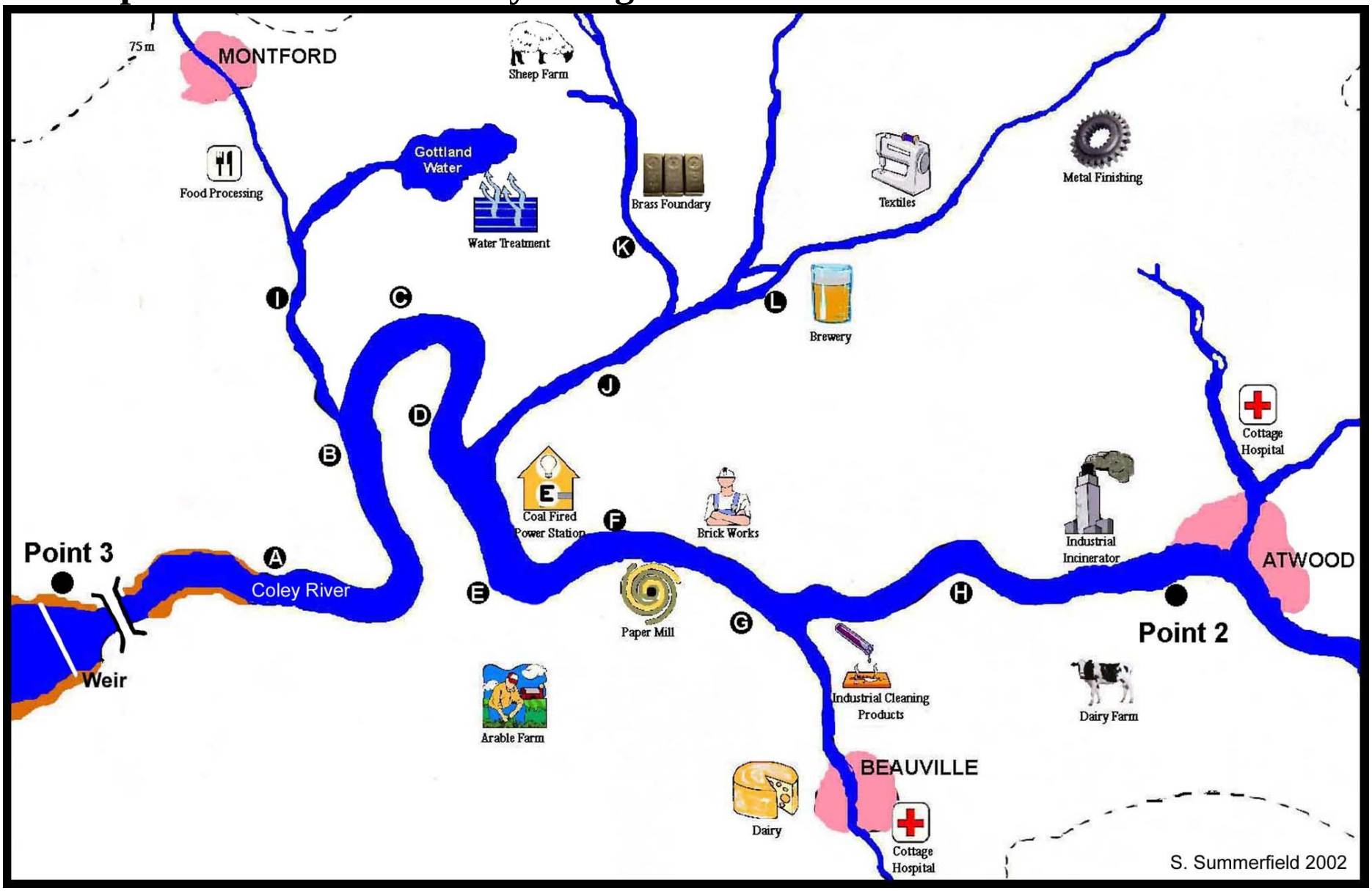
Sampling the River

1. Study the results that you have already received.

2. Decide from which three of the twelve points (A to L) you wish to sample.

3. Decide what tests you wish to perform on the three water samples.

Map of river between Coley Bridge and Atwood



Analytical Request Form B

Request submitted by Investigation Group ……..:

You may request up to three analyses. Each analysis will be carried out on each of three samples.

What are you looking for?	Method of Analysis?	Which three samples?
1.		
2.		
3.		

Is there one other type of sample you wish to analyse and for what?

_____

_____

Signed: _____ _____

_____ _____

_____ _____

Dated: _____

Remediation

The remediation methods employed for the types of pollution are given below.

Soluble Substances

Remediation	Pollution Factor	Examples
Precipitation	Toxic & non-toxic metals precipitated at certain pH	Al, Hg, Pb, Cr, Cd, Cu, Zn, Fe, Ti, Ni, Be
	Anions	PO_4^{2-}, SO_4^{2-}, SO_3^{2-}, F^-
Aeration or stripping	Gases & dissolved organics	H_2S, NH_3, SO_2, phenols, light or aromatic hydrocarbons and chlorinated derivatives.
Redox	Cations and anions	CN^-, Cr(VI), S^{2-}, Cl_2, NO_2^-
Neutralisation	Mineral acids and base	Hydrochloric, nitric, sulphuric and hydrofluoric acid. Miscellaneous bases
Substances concentrated by ion exchange and reverse osmosis	Radionuclides	I*, Mo*, Cs*
	Ion exchange	Salts of strong acids and bases. Also, ionised organic compounds.
	Reverse osmosis	non-ionised organic compounds
Biodegradation	Biodegradable substances	Sugars, proteins, and phenols. After acclimatisation, some organic compounds such as formaldehyde, aniline, detergents and even aromatic hydrocarbons may be oxidised. Also some mineral compounds ($S_2O_3^{2-}$, SO_3^{2-})
	Colour	Industrial effluents heavily coloured by colloids (pigments, sulphides) or dissolved substances (dyes, organic matter, nitrated derivatives)

Insoluble

Remediation	Pollution Factor	Examples
Separated with or without flocculation.	Floating greasy matter	Greases, aliphatic hydrocarbons, tar, organic oils, resins etc.
	Solids in suspension	Sands, oxides, hydroxides, pigments, colloidal sulphur, latex, fibres, filtration aids etc.)
	Organic substances separable by absorption	Dyes, detergents, miscellaneous macromolecules including phenoxylated, nitrated and chlorinated aromatic derivatives.

Submit a report to the Midshire River Authority. In the report you should: -

1. **Identify the probable causes of the depletion in fish numbers?**
2. **Summarise the evidence that supports your conclusions.**
3. **Decide what further evidence you require.**
4. **Discuss how you would avoid problems from these sources of pollution in the future.**
5. **Indicate what remediation you would perform.**
6. **Briefly describe how you would monitor whether these measure are having any effect.**

Your report will be submitted on

Appendix B: Results

Part A (organic pollution)

Part B (inorganic pollution)

Point 2 Atwood	Water analysis by GC-MS (1/7/02)		
	1/7/00 ng/l	1/7/01 ng/l	1/7/02 ng/l
Dieldrin	<0.01	<0.01	<0.01
Dioxins	<0.05	<0.05	<0.05
Paraquat	<0.01	<0.01	<0.01
PAHs	0.15	0.23	0.18
PCBs	1.5	1.8	1.6
Phenols	<0.01	<0.01	<0.01
Total HCs	<0.1	<0.1	<0.1
Notes	Water samples taken at the Atwood Monitoring station Level of pollutants is at or below the detection limits. HCs = hydrocarbons, PAHs = polyaromatic hydrocarbons, PCB = polychlorobiphenyls, Dieldrin is a pesticide and Paraquat a herbicide.		

	Walking the river
Notes	The Coley river upstream of Atwood to Coley Bridge was walked. The loading of solids increased downstream where the tributary from Beauville joined the Coley River. Some foaming was also observed there. Algal growth was observed east of the paper mill until the tributary meets the Coley River.

Point 3 Coley Bridge	Water analysis by GC-MS (1/7/02)		
	1/7/00 ng/l	1/7/01 ng/l	1/7/02 ng/l
Dieldrin	0.01	<0.01	<0.01
Dioxins	<0.05	<0.05	0.05
Paraquat	<0.01	<0.01	<0.01
PAHs	0.45	0.53	0.48
PCBs	1.2	1.4	1.1
Phenols	0.02	<0.01	0.01
Total HCs	<0.1	0.1	<0.1
Notes	Water samples taken at the Coley Bridge Monitoring station < Level of pollutants is below the detection limits. HCs = hydrocarbons, PAHs = polyaromatic hydrocarbons, PCB = polychlorobiphenyls, Dieldrin is a pesticide and Paraquat a herbicide.		

	Analysis of sediment
Notes	The taking of core samples is very expensive and time consuming. To carry this out you would need to narrow down where you would wish to carry this out. It is only suitable for heavy metals, and insoluble organic species (e.g. polyaromatic hydrocarbons). These would be treated like soil samples so would need to undergo time consuming extraction procedures.

Point 3	Biotic data (Coley Bridge)		
	Tipulidae	Hydropsychidae	Glossiphoniidae
	Hydroptilidae	Asellidae	Oligochaeta
	Simuliidae	Polycentropidae	Sialidae
	Psychomyidae	Baetidae	Chironomidae
	Gammaridae	Nemouridae	Unionidae
Notes	This 'kick sample' of freshwater invertebrates was collected at Coley Bridge.		

Fish	1/7/00	1/7/01	1/7/02	18/8/02
Trout	15	14	2	0
Perch	11	10	13	3
Chub	0	3	12	5
Tench	0	6	26	8
Notes	Fish caught at the Coley Weir over 8 hours.			

Point 2	Biotic data (Atwood monitoring station)		
	Tipulidae	Baetidae	Physidae
	Sialidae	Polycentropidae	Neritidae
	Hydroptilidae	Haliplidae	Simuliidae
	Chironomidae	Viviparidae	Valvatidae
	Philopotamiidae	Limnephilidae	Oligochaeta
	Hirudidae		
Notes	This 'kick sample' of freshwater invertebrates was collected at Atwood monitoring station.		

Notes	

Trout	1/7/00	1/7/01	1/7/02	18/8/02
Population	15	14	2	0
	mg/kg	mg/kg	mg/kg	mg/kg
Dieldrin	0.004	0.003	0.002	-
Dioxins	<0.0005	<0.0005	<0.0005	-
Paraquat	0.011	0.013	0.045	-
PAHs	0.0015	0.0023	0.0018	-
PCBs	6.7	1.8	2.5	-
Phenols	<0.001	<0.001	0.002	-
Total HCs	<0.1	<0.1	<0.1	-
Notes	Fish caught at the Coley Weir over 8 hours. Analyses of their liver were carried out. HCs = hydrocarbons, PAHs = poly aromatic hydrocarbons, PCB = polychlorobiphenyls, Dieldrin is a pesticide. Paraquat is a herbicide.			

Chub	1/7/00	1/7/01	1/7/02	18/8/02
Population	0	3	12	5
	mg/kg	mg/kg	mg/kg	mg/kg
Dieldrin	-	0.001	0.002	0.001
Dioxins	-	<0.0005	0.0012	0.0056
PAHs	-	0.0023	0.0018	0.0016
Paraquat	-	0.022	0.062	0.069
PCBs	-	2.5	3.1	4.1
Phenols	-	0.003	<0.001	0.003
Total HCs	-	<0.1	<0.1	<0.1
Notes	Fish caught at the Coley Weir over 8 hours. Analyses of their liver were carried out. HCs = hydrocarbons, PAHs = poly aromatic hydrocarbons, PCB = polychlorobiphenyls, Dieldrin is a pesticide. Paraquat is a herbicide.			

Perch	1/7/00	1/7/01	1/7/02	18/8/02
Population	11	10	13	3
	mg/kg	mg/kg	mg/kg	mg/kg
Dieldrin	0.004	0.004	0.005	0.005
Dioxins	<0.0005	<0.0005	0.0010	0.0008
PAHs	0.0038	0.0043	0.0053	0.0046
Paraquat	0.023	0.018	0.056	0.069
PCBs	5.7	2.5	2.3	2.9
Phenols	<0.001	<0.001	<0.001	0.002
Total HCs	<0.1	<0.1	<0.1	<0.1
Notes	Fish caught at the Coley Weir over 8 hours. Analyses of their liver were carried out. HCs = hydrocarbons, PAHs = polyaromatic hydrocarbons, PCB = polychlorobiphenyls, Dieldrin is a pesticide. Paraquat is a herbicide.			

Tench	1/7/00	1/7/01	1/7/02	18/8/02
Population	0	6	26	8
	mg/kg	mg/kg	mg/kg	mg/kg
Dieldrin	-	0.003	0.004	0.003
Dioxins	-	<0.0005	0.0012	0.0016
PAHs	-	0.0018	0.0015	0.0026
Paraquat	-	0.024	0.113	0.126
PCBs	-	2.5	2.3	2.9
Phenols	-	<0.001	0.002	0.003
Total HCs	-	<0.1	<0.1	<0.1
Notes	Fish caught at the Coley Weir over 8 hours. Analyses of their liver were carried out. HCs = hydrocarbons, PAHs = polyaromatic hydrocarbons, PCB = polychlorobiphenyls, Dieldrin is a pesticide. Paraquat is a herbicide.			

Appearance: Sample Point A:

BOD_5 mg/l	COD mg/l	Conductivity µS/cm	Ammonia (mg/l)	Dissolved O_2 % saturation	Appearance
4.4	2.2	1380	4.1	80	High loading of solids and no apparent odour

Appearance: Sample Point B

BOD_5 mg/l	COD mg/l	Conductivity µS/cm	Ammonia (mg/l)	Dissolved O_2 % saturation	Appearance
3.7	2.1	1605	2.9	82	High loading of solids and no apparent odour

Physical Data: Sample Point A

Temperature (°C)	pH	Suspended Solids mg/l	Ash from SS mg/l	Total alkalinity mg/l as $CaCO_3$
10.9	7.3	26.8	12.3	114.5

Physical Data: Sample Point B

Temperature (°C)	pH	Suspended Solids mg/l	Ash from SS mg/l	Total alkalinity mg/l as $CaCO_3$
11.4	7.3	24.9	10.4	116.9

Anions by Ion Chromatography: Sample Point A

Nitrite mg/l	Nitrate mg/l	Chloride mg/l	Orthophosphate mg/l	Sulphate mg/l	Cyanide mg/l	Anionic detergents
0.24	12.35	86.6	1.170	284	0.03	0.297

Anions by Ion Chromatography: Sample Point B

Nitrite mg/l	Nitrate mg/l	Chloride mg/l	Orthophosphate mg/l	Sulphate mg/l	Cyanide mg/l	Anionic Detergents
0.33	14.56	100.7	1.182	278	0.05	0.335

Metals by ICP-OES: Sample Point A

Aluminium mg/l (ppm)	Cadmium ng/l (ppt)	Chromium µg/l (ppb)	Copper mg/l (ppm)	Lead µg/l (ppb)	Mercury ng/l (ppt)	Nickel µg/l (ppb)	Tin µg/l (ppb)	Zinc mg/l (ppm)
0.06	190.0	9.0	0.0061	9.6	<1.0	11.3	0.007	0.346

Metals by ICP-OES: Sample Point B

Aluminium mg/l (ppm)	Cadmium ng/l (ppt)	Chromium µg/l (ppb)	Copper mg/l (ppm)	Lead µg/l (ppb)	Mercury ng/l (ppt)	Nickel µg/l (ppb)	Tin µg/l (ppb)	Zinc mg/l (ppm)
0.05	160.0	14.2	0.0041	4.6	<1.0	13.2	<0.005	0.297

Appearance: Sample Point C

BOD_5 mg/l	COD mg/l	Conductivity µS/cm	Ammonia (mg/l)	Dissolved O_2 % saturation	Appearance
3.7	1.9	1809	4.2	86	High loading of solids with some scum formation and no apparent odour

Appearance: Sample Point D

BOD_5 mg/l	COD mg/l	Conductivity µS/cm	Ammonia (mg/l)	Dissolved O_2 % saturation	Appearance
3.9	2.0	2408	4.3	72	High loading of solids, algal growth and slight organic odour.

Physical Data: Sample Point C

Temperature (°C)	pH	Suspended Solids mg/l	Ash from SS mg/l	Total alkalinity mg/l as $CaCO_3$
11.5	7.4	29.7	8.2	107.8

Physical Data: Sample Point D

Temperature (°C)	pH	Suspended Solids mg/l	Ash from SS mg/l	Total alkalinity mg/l as $CaCO_3$
11.3	7.4	31.2	9.0	106.6

Anions by Ion Chromatography: Sample Point C

Nitrite mg/l	Nitrate mg/l	Chloride mg/l	Orthophosphate mg/l	Sulphate mg/l	Cyanide mg/l	Anionic Detergents
0.29	17.95	92.1	1.271	256	0.04	0.389

Anions by Ion Chromatography: Sample Point D

Nitrite mg/l	Nitrate mg/l	Chloride mg/l	Orthophosphate mg/l	Sulphate mg/l	Cyanide mg/l	Anionic Detergents
0.21	21.38	105.1	1.242	250	0.05	0.457

Metals by ICP-OES: Sample Point C

Aluminium mg/l (ppm)	Cadmium ng/l (ppt)	Chromium µg/l (ppb)	Copper mg/l (ppm)	Lead µg/l (ppb)	Mercury ng/l (ppt)	Nickel µg/l (ppb)	Tin µg/l (ppb)	Zinc mg/l (ppm)
0.03	130.0	10.5	0.0065	7.8	2.4	13.6	<0.005	0.417

Metals by ICP-OES: Sample Point D

Aluminium mg/l (ppm)	Cadmium ng/l (ppt)	Chromium µg/l (ppb)	Copper mg/l (ppm)	Lead µg/l (ppb)	Mercury ng/l (ppt)	Nickel µg/l (ppb)	Tin µg/l (ppb)	Zinc mg/l (ppm)
0.02	110.0	17.7	0.0112	3.2	5.9	14.6	0.007	0.203

Appearance: Sample Point E

BOD_5 mg/l	COD mg/l	Conductivity µS/cm	Ammonia (mg/l)	Dissolved O_2 % saturation	Appearance
5.5	2.4	470	4.9	85	High loading of solids, algal growth and slight organic odour.

Appearance: Sample Point F

BOD_5 mg/l	COD mg/l	Conductivity µS/cm	Ammonia ((mg/l)	Dissolved O_2 % saturation	Appearance
3.9	1.8	486	2.0	93	High loading of solids with some scum formation and no apparent odour

Physical Data: Sample Point E

Temperature (°C)	pH	Suspended Solids mg/l	Ash from SS mg/l	Total alkalinity mg/l as $CaCO_3$
12.9	7.4	35.5	28.0	109.0

Physical Data: Sample Point F

Temperature (°C)	pH	Suspended Solids mg/l	Ash from SS mg/l	Total alkalinity mg/l as $CaCO_3$
11.4	7.4	42.5	8.5	94.9

Anions by Ion Chromatography: Sample Point E

Nitrite mg/l	Nitrate mg/l	Chloride mg/l	Orthophosphate mg/l	Sulphate mg/l	Cyanide mg/l	Anionic Detergents
0.27	41.38	91.0	0.990	222	0.01	0.285

Anions by Ion Chromatography: Sample Point F

Nitrite mg/l	Nitrate mg/l	Chloride mg/l	Orthophosphate mg/l	Sulphate mg/l	Cyanide mg/l	Anionic Detergents
0.23	13.81	68.4	0.964	227	0.01	0.353

Metals by ICP-OES: Sample Point E

Aluminium mg/l (ppm)	Cadmium ng/l (ppt)	Chromium µg/l (ppb)	Copper mg/l (ppm)	Lead µg/l (ppb)	Mercury ng/l (ppt)	Nickel µg/l (ppb)	Tin µg/l (ppb)	Zinc mg/l (ppm)
0.01	156.0	1.9	<0.0001	5.6	4.0	8.6	0.010	0.220

Metals by ICP-OES: Sample Point F

Aluminium mg/l (ppm)	Cadmium ng/l (ppt)	Chromium µg/l (ppb)	Copper mg/l (ppm)	Lead µg/l (ppb)	Mercury ng/l (ppt)	Nickel µg/l (ppb)	Tin µg/l (ppb)	Zinc mg/l (ppm)
<0.01	95.4	2.2	<0.0001	7.2	4.9	9.3	0.008	0.347

Appearance: Sample Point G

BOD_5 mg/l	COD mg/l	Conductivity µS/cm	Ammonia (mg/l)	Dissolved O_2 % saturation	Appearance
3.5	2.0	401	1.6	92	High loading of solids with some foaming and no apparent odour.

Appearance: Sample Point H

BOD_5 mg/l	COD mg/l	Conductivity µS/cm	Ammonia (mg/l)	Dissolved O_2 % saturation	Appearance
2.3	1.5	389	0.1	92	Clear translucent water with low loading solids and no apparent odour.

Physical Data: Sample Point G

Temperature (°C)	pH	Suspended Solids mg/l	Ash from SS mg/l	Total alkalinity mg/l as $CaCO_3$
11.5	7.3	16.2	18.7	99.7

Physical Data: Sample Point H

Temperature (°C)	pH	Suspended Solids mg/l	Ash from SS mg/l	Total alkalinity mg/l as $CaCO_3$
10.2	7.5	10.7	9.1	108.7

Anions by Ion Chromatography: Sample Point G

Nitrite mg/l	Nitrate mg/l	Chloride mg/l	Orthophosphate mg/l	Sulphate mg/l	Cyanide mg/l	Anionic Detergents
0.27	14.02	72.5	1.049	142	0.02	0.535

Anions by Ion Chromatography: Sample Point H

Nitrite mg/l	Nitrate mg/l	Chloride mg/l	Orthophosphate mg/l	Sulphate mg/l	Cyanide mg/l	Anionic Detergents
0.08	14.91	64.8	0.957	143	0.01	0.093

Metals by ICP-OES: Sample Point G

Aluminium mg/l (ppm)	Cadmium ng/l (ppt)	Chromium µg/l (ppb)	Copper mg/l (ppm)	Lead µg/l (ppb)	Mercury ng/l (ppt)	Nickel µg/l (ppb)	Tin µg/l (ppb)	Zinc mg/l (ppm)
0.02	158.9	0.5	0.0009	4.3	6.0	4.6	0.009	0.257

Metals by ICP-OES: Sample Point H

Aluminium mg/l (ppm)	Cadmium ng/l (ppt)	Chromium µg/l (ppb)	Copper mg/l (ppm)	Lead µg/l (ppb)	Mercury ng/l (ppt)	Nickel µg/l (ppb)	Tin µg/l (ppb)	Zinc mg/l (ppm)
0.03	174.5	0.2	0.0005	5.9	8.5	3.4	<0.005	0.450

Appearance: Sample Point I

BOD_5 mg/l	COD mg/l	Conductivity µS/cm	Ammonia (mg/l)	Dissolved O_2 % saturation	Appearance
2.8	1.4	220	0.2	97	Clear translucent water with low loading solids and no apparent odour.

Appearance: Sample Point J

BOD_5 mg/l	COD mg/l	Conductivity µS/cm	Ammonia (mg/l)	Dissolved O_2 % saturation	Appearance
3.1	1.8	2790	2.1	52	High load of solids, when settled water was a slightly greenish in colour and some scum formation. No apparent odour.

Physical Data: Sample Point I

Temperature (°C)	pH	Suspended Solids mg/l	Ash from SS mg/l	Total alkalinity mg/l as $CaCO_3$
10.7	8.1	4.5	4.5	106.4

Physical Data: Sample Point J

Temperature (°C)	pH	Suspended Solids mg/l	Ash from SS mg/l	Total alkalinity mg/l as $CaCO_3$
11.9	7.4	66.7	23.2	93.1

Anions by Ion Chromatography: Sample Point I

Nitrite mg/l	Nitrate mg/l	Chloride mg/l	Orthophosphate mg/l	Sulphate mg/l	Cyanide mg/l	Anionic Detergents
0.07	23.74	30.1	0.647	111	<0.01	0.056

Anions by Ion Chromatography: Sample Point J

Nitrite mg/l	Nitrate mg/l	Chloride mg/l	Orthophosphate mg/l	Sulphate mg/l	Cyanide mg/l	Anionic Detergents
0.19	20.95	62.4	2.502	501	0.15	0.565

Metals by ICP-OES: Sample Point I

Aluminium mg/l (ppm)	Cadmium ng/l (ppt)	Chromium µg/l (ppb)	Copper mg/l (ppm)	Lead µg/l (ppb)	Mercury ng/l (ppt)	Nickel µg/l (ppb)	Tin µg/l (ppb)	Zinc mg/l (ppm)
0.04	98.4	<0.1	0.0010	1.1	<1.0	12.4	<0.005	0.088

Metals by ICP-OES: Sample Point J

Aluminium mg/l (ppm)	Cadmium ng/l (ppt)	Chromium µg/l (ppb)	Copper mg/l (ppm)	Lead µg/l (ppb)	Mercury ng/l (ppt)	Nickel µg/l (ppb)	Tin µg/l (ppb)	Zinc mg/l (ppm)
0.01	119.9	44.0	0.0320	2.1	<1.0	25.7	0.009	0.067

Appearance: Sample Point K

BOD_5 mg/l	COD mg/l	Conductivity µS/cm	Ammonia (mg/l)	Dissolved O_2 % saturation	Appearance
2.1	1.1	321	0.1	98	Clear translucent water with low loading solids and no apparent odour.

Appearance: Sample Point L

BOD_5 mg/l	COD mg/l	Conductivity µS/cm	Ammonia ((mg/l)	Dissolved O_2 % saturation	Appearance
3.5	1.7	3698	1.7	41	High load of solids, when settled water was a slightly greenish in colour and some foaming. No apparent odour.

Physical Data: Sample Point K

Temperature (°C)	pH	Suspended Solids mg/l	Ash from SS mg/l	Total alkalinity mg/l as $CaCO_3$
11.3	8.3	3.2	1.1	118.7

Physical Data: Sample Point L

Temperature (°C)	pH	Suspended Solids mg/l	Ash from SS mg/l	Total alkalinity mg/l as $CaCO_3$
12.3	7.4	75.1	28.3	89.7

Anions by Ion Chromatography: Sample Point K

Nitrite mg/l	Nitrate mg/l	Chloride mg/l	Orthophosphate mg/l	Sulphate mg/l	Cyanide mg/l	Anionic Detergents
0.07	36.05	35.7	0.875	123	<0.01	0.065

Anions by Ion Chromatography: Sample Point L

Nitrite mg/l	Nitrate mg/l	Chloride mg/l	Orthophosphate mg/l	Sulphate mg/l	Cyanide mg/l	Anionic Detergents
0.21	19.64	88.6	3.158	525	0.21	0.685

Metals by ICP-OES: Sample Point K

Aluminium mg/l (ppm)	Cadmium ng/l (ppt)	Chromium µg/l (ppb)	Copper mg/l (ppm)	Lead µg/l (ppb)	Mercury ng/l (ppt)	Nickel µg/l (ppb)	Tin µg/l (ppb)	Zinc mg/l (ppm)
0.02	97.2	2.2	0.0090	1.4	<1.0	2.3	0.011	0.074

Metals by ICP-OES: Sample Point L

Aluminium mg/l (ppm)	Cadmium ng/l (ppt)	Chromium µg/l (ppb)	Copper mg/l (ppm)	Lead µg/l (ppb)	Mercury ng/l (ppt)	Nickel µg/l (ppb)	Tin µg/l (ppb)	Zinc mg/l (ppm)
0.04	116.8	76.0	0.0304	2.2	<1.0	29.1	0.008	0.068

Appearance for Points 1-4

Point	BOD mg/l	COD mg/l	Conductivity µS/cm	Ammonia mg/l	Dis O_2 % Sat	Appearance and odour
1	1.7	0.8	380	0.2	98	Sample was clear with low suspended solids and no apparent odour
2	1.6	0.9	398	0.4	93	Sample was clear with low suspended solids and no apparent odour
3	4.6	2.4	1465	4.7	64	High loading of solids that settled after a few minutes and some white scum on the surface. No apparent odour.
4	9.8	4.8	>5000	6.4	50	Turbid water that quickly settled. Some oil present on the surface and slightly unpleasant odour.

Physical Data for Points 1-4

Point	Temperature (°C)	pH	Suspended Solids mg/l	Ash from SS mg/l	Total alkalinity mg/l as $CaCO_3$
1	10.1	7.5	8.4	6.4	103.4
2	10.3	7.4	7.9	6.5	102.1
3	10.8	7.3	28.2	14.3	112.4
4	8.6	8.9	>100	12.3	>120.0

Anions for Points 1-4

Point	Nitrite mg/l	Nitrate mg/l	Chloride mg/l	Orthophosphate mg/l	Sulphate mg/l	Cyanide mg/l	Anionic Detergents
1	0.03	12.46	35.2	0.089	125	<0.01	0.018
2	0.06	13.42	43.4	0.169	131	<0.01	0.022
3	0.23	12.46	95.3	1.481	297	0.03	0.202
4	>1.0	>50	>350	1.271	>500	0.04	0.123

Metals for Points 1-4

Point	As µg/l	Al mg/l	Cd ng/l	Cr µg/l	Cu µg/l	Pb µg/l	Hg ng/l	Ni µg/l	Sn µg/l	Zn mg/l
1	<0.1	0.04	145.6	0.2	<0.1	2.9	4.0	4.3	<0.005	0.367
2	<0.1	<0.01	117.2	<0.1	<0.1	4.0	5.0	5.2	<0.005	0.256
3	9.0	0.02	147.1	11.0	7.4	10.2	6.4	19.6	0.11	0.296
4	8.4	0.03	163.2	14.0	6.3	8.1	10.0	32.6	0.12	0.478

Fish (Metals)

	As mg/kg	Cd µg/kg	Cr mg/kg	Cu mg/kg	Pb mg/kg	Hg µg/kg	Ni mg/kg	Sn mg/kg	Zn mg/kg	No.
1/7/2000: Fish caught at Coley Bridge. Metals were determined from the fish muscle by ICP-OES.										
Trout	1.0	2.12	0.12	33	7.6	91	0.551	0.021	33.41	15
Perch	1.2	2.19	0.18	44	7.2	86	0.554	0.021	43.46	11
Chub	-	-	-	-	-	-	-	-	-	0
Tench	-	-	-	-	-	-	-	-	-	0
1/7/2001: Fish caught at Coley Bridge. Metals were determined from the fish muscle by ICP-OES.										
Trout	1.8	2.46	0.13	87	8.7	122	0.322	0.009	34.87	14
Perch	2.2	3.18	0.14	94	8.4	103	0.318	0.009	43.84	10
Chub	1.2	2.48	0.12	118	8.9	139	0.278	0.009	45.82	3
Tench	2.5	2.41	0.14	102	9.0	112	0.198	0.009	44.88	6
1/7/2002: Fish caught at Coley Bridge. Metals were determined from the fish muscle by ICP-OES.										
Trout	-	-	-	-	-	-	-	-	-	2
Perch	1.2	3.00	1.12	168	9.1	123	1.432	0.012	44.59	13
Chub	1.1	2.85	1.63	133	8.8	89	1.439	0.008	45.54	12
Tench	1.4	3.03	1.37	211	7.6	161	1.435	0.012	35.52	26
18/8/2002: Fish caught at Coley Bridge. Metals were determined from the fish muscle by ICP-OES.										
Trout	-	-	-	-	-	-	-	-	-	0
Perch	1.2	2.36	5.08	428	8.8	88	1.332	0.010	45.44	3
Chub	1.5	3.13	6.03	431	8.0	131	1.267	0.015	34.47	5

Tench	0.8	2.38	4.34	440	8.9	102	1.432	0.014	45.49	8

Appendix C: Exercises

Organic Analysis

Which techniques are suitable for the analysis the following? Indicate the detectors you would choose. Remember that most compounds can be analysed by many different methods.

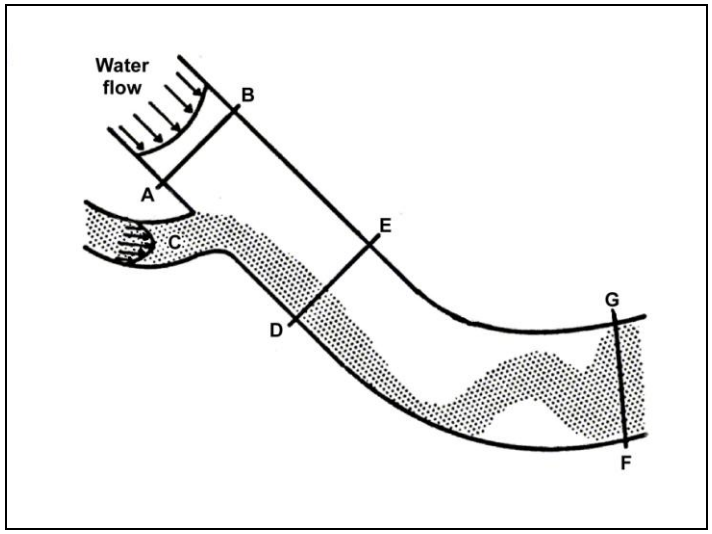
Analyte	Colorimetric	Gas liquid chromatography (GLC)	GC-MS	High pressure liquid chromatography	HPLC-MS	Ion chromatography (IC)
2,4,6-trichlorophenol						
Acetic Acid						
Anthracene						
Chloroform						
Detergents						
Hexachlorobenzene						
Naphthalene						
Poly aromatic hydrocarbons (PAHs)						
Parathion herbicide						
Phenol						
Toluene						

Sampling an effluent from a factory

1. A point source is where a discharge location can be readily identified. Give two examples?

2. A diffuse source is where it is not possible to identify the precise discharge point. Give two examples?

Harmony Cleaning Products Ltd. produces industrial cleaning products and a range of hair care products and creams. There is a constant discharge of liquid into the local river. This consists of dyes and surfactants from the process and contaminants present in the starting materials (fats, grease etc.)



3. What would you think the discharge from Harmony Cleaning Products Ltd. would look like?

4. Where do you sample so that you could gauge the base levels for the river?
   a. **Up-stream (A-B)**
   b. **At the Outflow pipe (C)**
   c. **Downstream before the bend (D-E)**
   d. **Downstream after the bend in the river (F-G)**

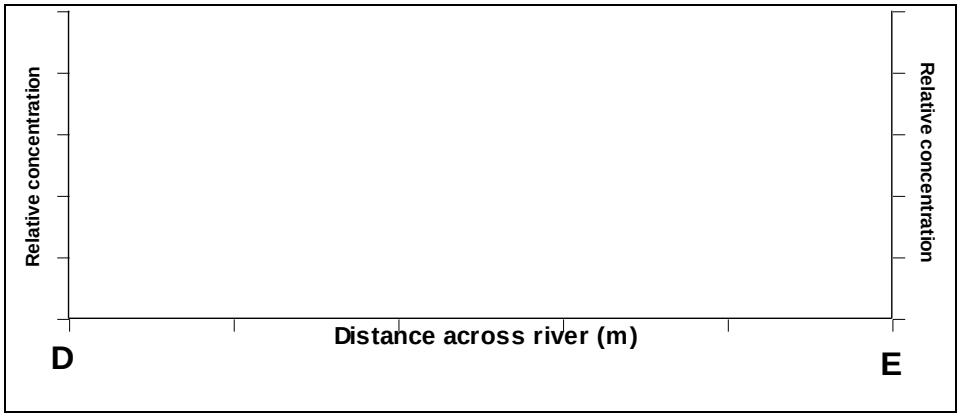
5. Where would you sample the outflow?
   a. **Up-stream (A-B)**
   b. **At the Outflow pipe (C)**
   c. **Downstream before the bend (D-E)**
   d. **Downstream after the bend in the river (F-G)**

6. Could this be related to the final concentration in the river? If so what further information would be required?

7. Where would you sample to get a direct measure of the concentration in the river?

a. **Up-stream (A-B)**
b. **At the Outflow pipe (C)**
c. **Downstream before the bend (D-E)**
d. **Downstream after the bend in the river (F-G)**

8. Draw a profile of the pollution levels at point D-E



9. If you only sampled at F-G, would you be certain of the location if the discharge point?

Inorganic Analysis (Cations)

Which techniques are suitable for the analysis of cations in water? Remember many species can be analysed by more than one method.

Analyte	Titration	Colorimetry	Anodic stripping voltametry	Flame Photometer	Atomic absorption spectroscopy	Inductively coupled plasma (ICP)	Ion chromatography (cation)
Al^{3+}							
Ca^{2+}							
Cd^{2+}							
Cu^{2+}							
Fe^{3+}							

Hg^{2+}							
K^{+}							
Mg^{2+}							
Na^{+}							
Pb^{2+}							
Zn^{2+}							
NH_4^{+}							

Inorganic Analysis (Anions)

Which are suitable for the analysis of anions in water? Remember many species can be analysed by more than one method.

Analyte	Titration	Colorimetry	Ion selective electrode	Ion chromatography (anion)	Gravimetric
Chloride					
Cyanide					
Fluoride					
Nitrate					
Nitrite					
Phosphate					
Sulphate					
Sulphite					

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Title	Tales of the Riverbank Problem-Based Learning Case Study
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