Environmental and Ecological Field Skills: Assessment 2, Scientific Report

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Contents

Tables and Figures

Introduction

Gogo Water

Gogo Water is an approximately 6-mile-long river in the North Ayrshire Catchment of Scotland.

The river rises approximately 350m in altitude from the edge of the Clyde Muirshiel Regional Park, in a valley of raised and blanket bogs between Irish Law and Windy Rise.

It then flows South-West down and over several waterfalls picking up smaller tributaries like the Slaty Burn through areas of mixed grassland. From here it continues flowing Westerly where it meets its main tributary the Greeto Water.

The final stretch of the river continues flowing West through a deep valley of grassland and deciduous woodland before exiting in the Firth of Clyde via the small seaside town of Largs, North Ayrshire.

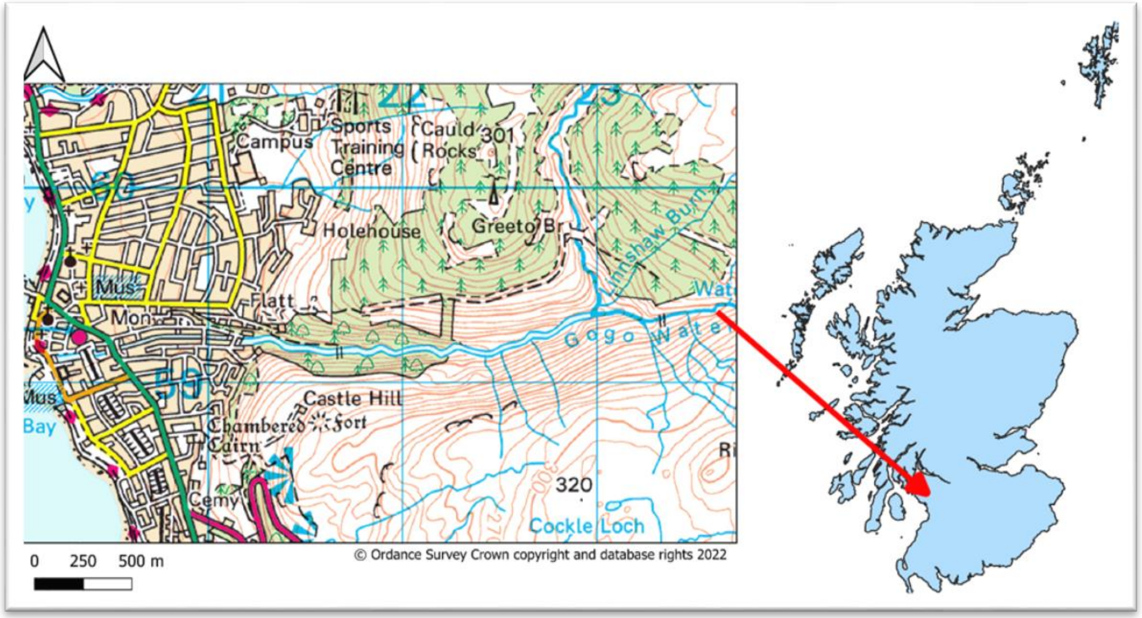


Figure 1 - Gogo Water flowing through Largs, entering into the Firth of Clyde

Freshwater Threats

Fresh water systems like the Gogo Water and its tributaries are under constant pressure from anthropogenic changes such as land-use change. From the journal "Aquatic Conversation" it was discussed how the biodiversity of freshwater aquatic systems can be altered from the changing of natural lands to urban, industrialised and agricultural land uses.

The same journal article also concluded that when a catchment lost 10% of its natural landscape, it led to a loss of 6% (+ or – 0.83%) of native macroinvertebrates and freshwater fish species (Weijters et al., 2009).

Similarly, another journal article from "Biological Review" states that freshwater systems take around 2.3% of the worlds landmass, yet hosts almost 10% of Earths described animal species, confirming how important these habitats are.

It then goes onto state that freshwater habitats are also at a higher risk and face higher pressures via extinction and habitat degradation than any other ecosystems, and that these threats will only be intensified as we continue the exploitation of the worlds freshwater habitat systems. These threats can be from contaminants and pollutants from run-off, salination of freshwater rivers and the expansion of hydropower amongst others (Reid et al., 2019).

The Brief

The investigative brief was to establish *"the current ecological diversity, land use and quality of the immediate catchment area of the Gogo Burn, and how could this affect the freshwater system?".*

Figure 2 shows the final ~2 mile stretch of the Gogo Water, with varying land types such as built-up, existing & new woodlands, and mixed grasslands. The main land uses identified along the Gogo Water were urban living, recreation and light industry. Due to budget and time constraints, it was decided to only focus on the final ~1.75 mile stretch of the river.

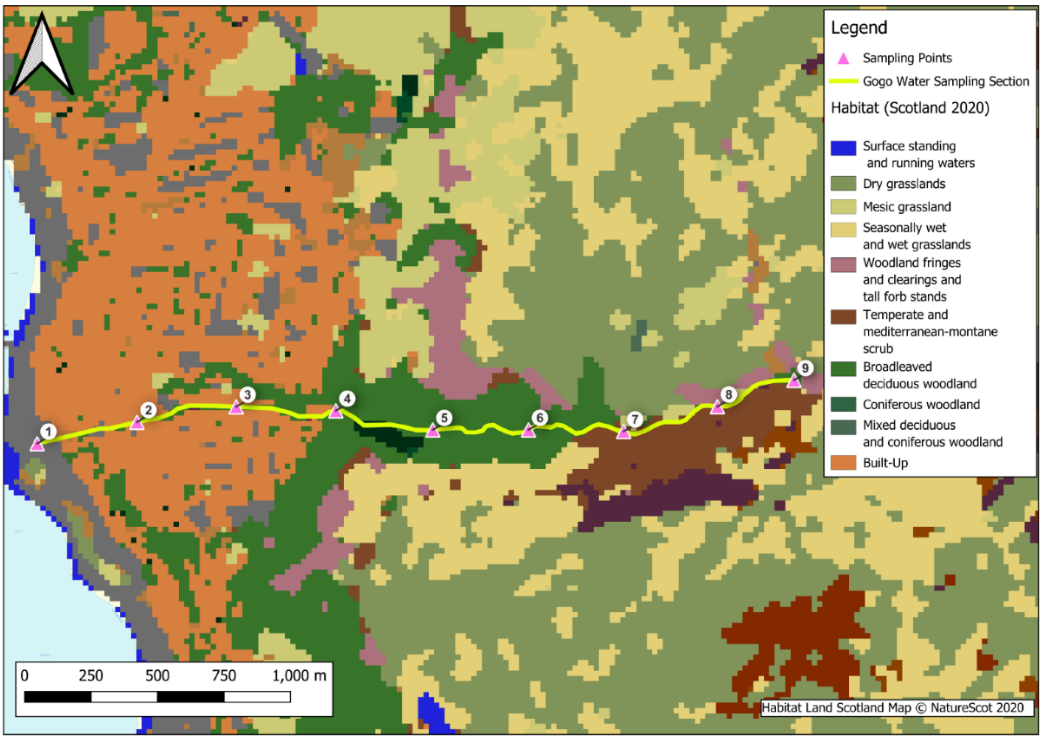


Figure 2 - Three land types, Gogo Water (yellow) and sample locations.

The team, consisting of Scott Barclay, Hannah Edgar and Finlay White, opted for both a scientific approach manually surveying different aspects of the Gogo Water via kick sampling and turbidity testing, as well as a more overall holistic approach utilising geospatial analytical tools, to establish if there was a difference in water quality and freshwater invertebrates' quantities between the different identified land types.

This data would then be used to identify the different pressures and influences of the land use on Gogo Water and how we can plan, mitigate and adapt to these pressures for the benefit of the freshwater ecosystem.

Aims and Objectives

Aim

The main aim of the project was to determine the overall quality of the Gogo Water and to establish if the different land use changes and land uses have any influence over the overall quality of the freshwater system. This is to be done via manual on-site surveying of the Gogo Water, manual on-site observation of the immediate catchment land characteristics, and via remote geospatial analysis using 3rd party data sources.

Objectives

1) Establish what immediate catchment is and what stretch of the Gogo Water is to be surveyed before Project Plan submission deadline (Friday 1st Feb 2024).
2) Identify ecological diversity and different land use and quality of the immediate catchment via spatial analysis before Project Plan submission deadline (Friday 1st Feb 2024).
3) Manually survey the Gogo Water via agreed methods on Tuesday 19th March between 9.30am and 3.30pm.
4) Analyse any findings from the manual Gogo Water survey on Thursday 21st (early evening).
5) Further our knowledge of the Gogo Water and immediate catchment.
6) Use findings to plan accordingly, specifically to mitigate against any poorer aspects of the river.
7) Protect and enhance the overall quality of the freshwater system going forward using these findings for better planning and conservation policies.

Methods

To meet objectives 1 and 2, given the time constraints on the day of surveying it was decided to survey the last 1.75 miles of the Gogo Water. This was chosen because that distance was broken into 3 near equal sections of different land types; Built-up, woodland and grassland. This was identified using QGIS and Habitat Scotland Map layer from NatureScot (NatureScot, 2024)

From viewing Ordnance Survey maps it was also identified that this 1.75 mile stretch covered different land uses; urban living, nature/recreation via core path network and light industry with hydro power installed at 2 locations on this stretch (Ordnance Survey, 2022)

To meet objective 3, utilising QGIS and OS mapping (See Appendix 6 for hardware and software used), the surveying took place over 9 sampling locations. This was decided as it allowed for 3 sampling locations at each of the 3 different land types (built-up, woodland and grassland) at near equal ~385m intervals, see Figure 3.

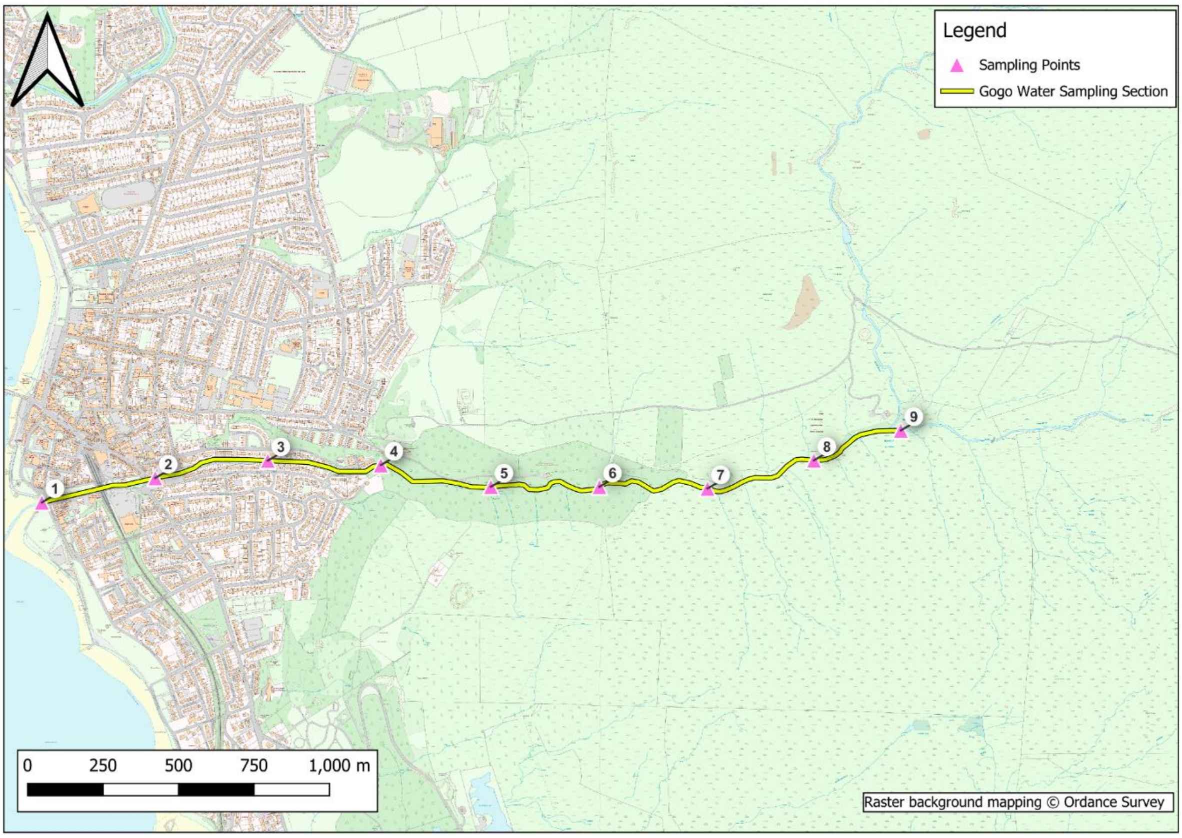


Figure 3 – Sample 1-3 – Build-up, Samples 4-6 – Woodland, Samples 7-9 – Grassland.

Kick sampling and turbidity testing was undertook at each sample location. These were chosen as kick sampling, via key indicator species can provide quick information on overall river water quality (UKCEH, 2022). Turbidity testing was conducted to see if there was a difference in water turbidity between the 3 different land types and any correlation between turbidity levels and macroinvertebrate species and abundance (See Appendix 5 for surveying kit list).

Figure 4 - Kick sampling in action (Source: Hannah Edgar)

Kick sampling was conducted by kicking the bed of the river for 3 minutes with a net facing downstream which Figure 4 demonstrates, with 7 minutes spent identifying the catch by 2 members which Figure 5 shows. While this was ongoing, the third member conducted turbidity testing via a filling a turbidity test tube, like Figure 6, with river water and noting when they could no longer see the bottom of the tube from looking down it. This was replicated at each of the 9 sample sites.

Figure 5 - Kick sampling catch inspection (Source: Scott Barclay)

Figure 6 - Turbidity test tube (Source: amazon.co.uk)

To meet objective 4 the recorded data from surveying was analysed via the VEGAN package in R Studio. This was chosen as VEGAN in conjunction with R can provide Diversity analysis (Simpsons) which calculates species abundance and richness (Kiernan, 2024) while Dissimilarity analyses (ANOVA) can tell if there are any statistical differences between the means of the three chosen land types (groups) (Sullivan, n.d.). Further discussion on this can be found in the Results section below.

To meet objectives 5-7, all data from objectives 1-4 as well as all information from the Results, Discussion and Conclusions sections below can be used to help mitigate, adapt and plan to improve the overall quality of Gogo Water.

Results

Kick Sampling – Species Count

Table 1 - Kick sampling results

Sample Point (Land type)	Invertebrate Species											
	Flattened Mayfly	Swimming Mayfly	Stonefly Nymph	Shrimp	Worm	Water Beetle	Beetle Larvae	Nonbiting Midge Larvae	Springtail	Freshwater Crayfish	Leech	Caseless Caddisfly larvae
1 (Built-up)	0	0	0	5	5	0	0	0	0	0	0	0
2 (Built-up)	3	0	1	0	1	0	1	0	0	0	0	0
3 (Built-up)	1	2	4	0	2	1	0	1	0	0	0	0
4 (Woodland)	0	0	0	0	0	0	0	1	1	0	0	0
5 (Woodland)	0	1	0	0	0	0	0	0	0	0	0	0
6 (Woodland)	1	3	2	0	0	0	1	0	0	1	0	0
7 (Grassland)	4	3	3	0	0	0	0	0	0	0	1	1
8 (Grassland)	2	2	0	0	0	0	0	0	4	0	0	0
9 (Grassland)	4	2	1	0	0	0	0	1	0	0	1	0

Table 1 (above) shows the results of the kick sampling survey with a high abundance of mayfly (*Ephemeridae* and *Nesameletus*) and stone fly (*Plecoptera*) indicating good overall water quality of the surveyed stretch of Gogo Water (Voshell, 2002).

Kick Sampling – Simpsons Diversity Index

Table 2 - Kick sampling Simpsons Diversity Index

Sample Point (Land Type)	1 (Built-up)	2 (Built-up)	3 (Built-up)	4 (Woodland)	5 (Woodland)	6 (Woodland)	7 (Grassland)	8 (Grassland)	9 (Grassland)
Simpson's Diversity Index	0.5	0.6666667	0.7768595	0.5	0	0.75	0.75	0.625	0.7160494
Average	0.647842067			0.416666667			0.697016467		

Simpsons Diversity Index scores from Table 2 shows the degree of diversity between the 3 land types. A score of 0 is no diversity/absolute uniformity with 1 being absolute diverse. Built-up and Grassland averages of 0.647 and 0.697 respectively, are very similar and show they have some diversity. Woodland with 0.416 looks low in diversity with diversity than the other land types. However, this will be discussed further in the Discussions section (Searl, 2019). See Appendix 2 for R script used.

Turbidity Testing

Table 3 - Turbidity testing results

Sample Point (Land Type)	1 (Built-up)	2 (Built-up)	3 (Built-up)	4 (Woodland)	5 (Woodland)	6 (Woodland)	7 (Grassland)	8 (Grassland)	9 (Grassland)
Turbidity Units (NTU)	100	5	10	5	10	10	5	10	10
Average (NTU)	38.33			8.33			8.33		

At all locations, bar sample point 1 which will be further discussed below, the turbidity of water was consistent with scores of between 5-10. Woodland and Grassland had the exact same average NTU score, showing there was no different in water turbidity between those two land types. For reference, UN turbidity levels for drinking water is <5, while across the United Kingdom it is <1 (Welsh Government, 2020).

MANOVA

```
Response Turbidity :
            Df Sum Sq Mean Sq F value Pr(>F)
LandUse      2   1800  900.00  0.9391 0.4417
Residuals    6   5750  958.33

 Response Diversity :
            Df  Sum Sq  Mean Sq F value Pr(>F)
LandUse      2 0.13446 0.067228  1.1903  0.367
Residuals    6 0.33888 0.056480
```

Utilising R Studio (See Appendix 3 for R script used), MANOVA was conducted and shows there is no significant difference between Turbidity and Simpsons diversity across the land uses.

Regression Analysis

```
            Df Sum Sq Mean Sq F value Pr(>F)
LandUse      2 0.1345 0.06723    1.19  0.367
Residuals    6 0.3389 0.05648
```

Regression Analysis, see Appendix 4 for script used, shows no correlation between water turbidity and macroinvertebrate diversity in the Gogo Water.

Visualising the data

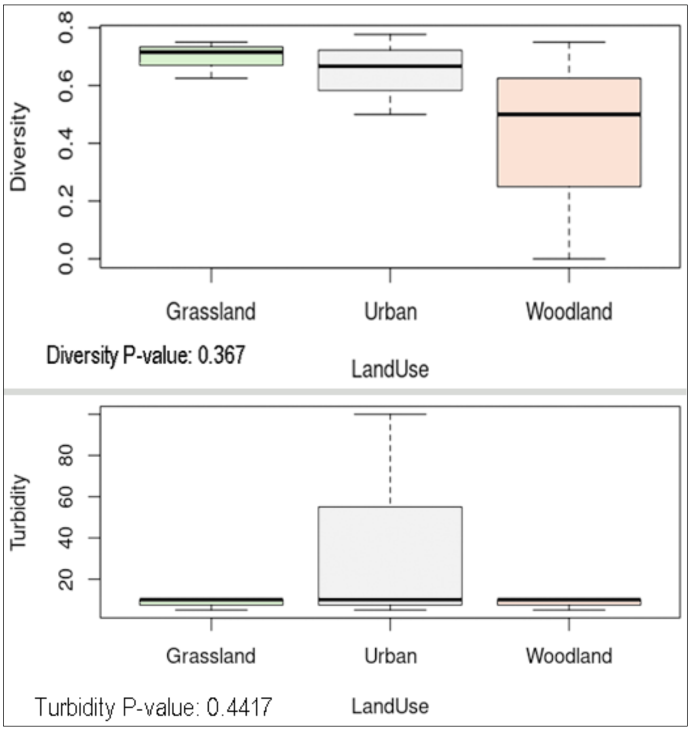


Figure 7 - Visualisation of data showing box plots

Figure 7 shows for diversity, there is little difference in median for Grassland and Urban with Woodland scoring slightly lower. Woodland has greater variance in the data (larger box) with larger outliers.

For turbidity there is little difference in median for all 3 land types, however Urban has more variable data with larger outliers also. This will be discussed further in “Discussions”.

Discussion

River Surveying

From the original brief discussed under “Introduction – The Brief”, the following alternative hypothesis was formulated *“There is a difference in overall water quality and turbidity in 3 varying built-up, woodland and grassland land types along the Gogo Burn”.*

After analysing the data, the study of overall water quality of Gogo Water between different land types is inconclusive. This is because of potential bias with sample locations due to difficulty accessing 6 out of the 9 sample locations due to steep terrain and/or extremely fast flowing water.

Another reason is surveying errors on the day. Table 1 shows little species and abundance for the kick sampling conducted in the Woodland areas. This can be largely attributed to the only safe sampling locations within the Woodland area being very straight and fast canalised sections flowing over bedrock with no gravel or small stones, resulting in poor habitat for macroinvertebrates, but not necessarily contributing to the overall water quality, which Table 2 demonstrates with Woodland land type having a lower average Simpsons 1-D score than built-up and grassland.

Similarly, Table 3 has a huge outlier of the turbidity NTU level for sample location 1 in the built-up area. This sample location is where Gogo Water enters Firth of Clyde, so the turbidity tube was filled with sand as we conducted the test, giving a higher score. Furthermore, it was established by the research group that ease of reading turbidity levels depended on natural light. Conducting this test seemed easier in open built-up and grassland areas, compared to areas of dense woodland with low light levels, again, contributing to the inconclusive result.

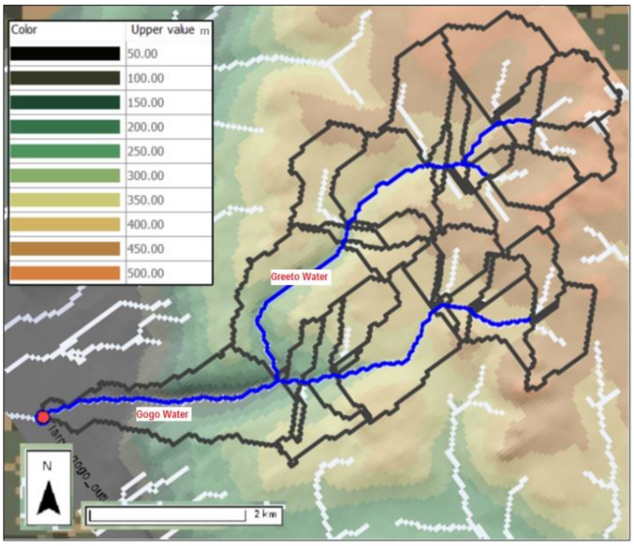
In hindsight, and from reading “River Data Collection Guide”, to overcome this there should’ve been more sample locations with variation of samples taken in the Gogo Water (CIWEM, 1998), the surveying done was mostly undertook on the north-side of the river, neglecting the central and southern sections of Gogo Water.

Turbidity testing should’ve been conducted following best practices of similar studies, using a digital portable tester (Lawler et al., 2006) such as NEP390 Handheld Turbidity Meter, allowing for more accurate and consistent results.

The research group should’ve also conducted more sampling, looking at water flow, particularly around the areas of hydropower and water depth, as this can directly affect overall water quality and macroinvertebrates (Xiaocheng et al., 2008), while also affecting these things indirectly via contributing to changes of water temperature (DURANCE & ORMEROD, 2009).

Immediate Land Use

Via spatial analysis and on-site surveying, the wider catchment of the Gogo Water was surveyed to see how this could influence the overall water quality of the freshwater environment.



A stream analysis was conducted via modelling on HEC-HMS.

The white lines within the black sub-basin on Figure 8 shows drainage channels from the near-by hills of blanket bog.

The blanket bog quality could affect the overall water quality by affecting the hydrology directly or indirectly, by increasing or decreasing the storage of rain fall.
(Boelter, 1964)

Figure 8 - Stream analysis via HEC-HMS

Furthermore, via the Scottish Government's Forestry Grand Scheme, as Figure 9 shows, it was established that 550 hectares of land has been claimed round the Gogo Water and tributaries for re-forestation projects (NatureScot, 2023), with planting already underway as Figure 10 demonstrates. Previous studies have shown re-forested areas to decrease and increase streamflow by around 3% depending on the season (Wangpimool et al., 2013).

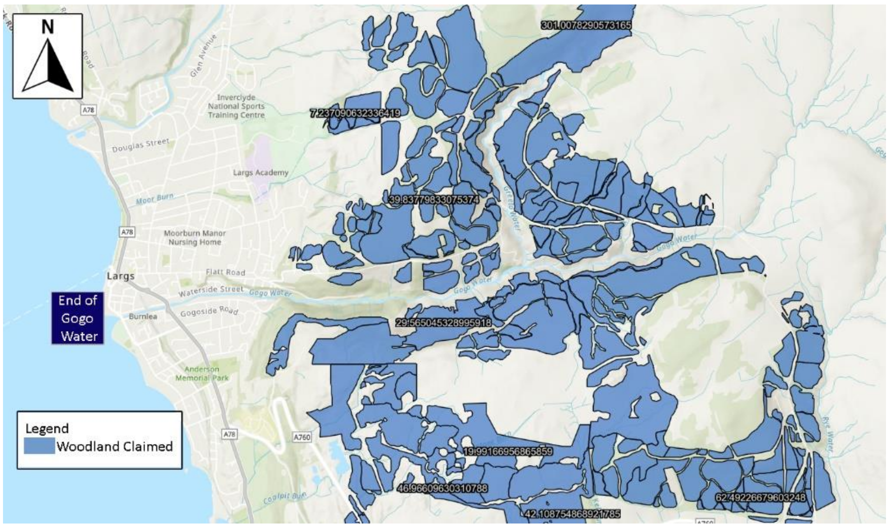


Figure 9 - Land claimed via FGS

Figure 10 - Tree planting directly on Gogo Water (Source: Hannah Edgar)

Via walking the accessible sections of the Gogo Water through the small town of Largs, and using 3rd party data, the research group sough to establish how the overall quality of the Gogo Water could be affected by urban living, which is shown by Figure 11.

Figure 11 - Gogo Water running directly through Largs (Source: Scott Barclay)

1) Straight canalised sections resulting in faster water, no pools or ripples, no meanders to trap sediment, no gravel bars, little vegetation for food and shelter, can be ecology poor (IUCN, 2016).
2) Metal particulates such as lead from the builder's yard and road-run off directly entering Gogo Water may affect invertebrate species as previous studies have shown (Perdikaki & Mason, 1999).
3) SEPA states that there is "several combined sewer and emergency overflows within Largs" and that these can discharge to the main watercourses, which includes Gogo Water during intense rainfall events (SEPA, 2023). Previous studies have shown that CSO discharge can include microbial pathogens, PAHs (polycyclic aromatic hydrocarbons) and MTEs (metallic trace elements), as well as human fecal matter and household and business chemicals, all of which can harm aquatic organisms while re-shaping microbial communities (Pozzi et al., 2024).

Conclusion

Despite the challenges and pressures on the Gogo Water, after the research conducted, the report finds that the overall condition of the river is good, with room for improvement, which is in line with SEPA who classify the overall condition of Gogo Water as "Moderate" as of 2022, which is an improvement of it being classed as Poor as in 2013 (see Appendix 7 for SEPA's classification of Gogo Water).

This conclusion can be reached via the kick sampling results, showing a high abundance of mayfly (*Ephemeridae* and *Nesameletus*) and stone fly (*Plecoptera*) which indicates good overall water quality (Voshell, 2002).

Furthermore, surveying of the river's turbidity was consistent with 8 out of 9 samples returning a result of between 5 – 10 NTU. No UK or Scottish could be obtained on acceptable NTU levels, however the Australian government states rural streams and rivers should be <10NTU with urban <30NTU, meaning turbidity levels for the Gogo Water seem acceptable to those standards (ACT Government, 2001).

Despite the overall condition of the Gogo Water, several challenges lay ahead, such as improving the overall hydromorphology of the river which SEPA classified as High in 2014 but downgraded to Moderate between 2022 and 2016 due to the installation of hydropower. These challenges could be further exacerbated by climate change (more or less rain) and re-forestation happening within the catchment further altering streamflow.

Despite best efforts the research group has concluded some mistakes were made, most notably sample locations. There should've been more survey locations, with closer attention paid to survey location accessibility, this should've been carried out on a pre-survey visit to the site.

It's also been acknowledged that to establish overall water quality, further testing should've been conducted on the Gogo Water, for things such as water temperature, flowrate, dissolved oxygen, acidity and pH to give a better understanding of the overall quality of the river.

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Appendix

Appendix 1 – Data source for R Studio analyse “Data Collection.xlsx”

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Site	Flattened Mayfly	Swimming Mayfly	Stonefly Nymph	Shrimp	Worm	Water Beetle	Beetle Larvae	Nonbiting Midge Larvae	Springtail	Freshwater Crayfish	Leech	Caseless Caddisfly larvae	Diversity	Turbidity	LandUse
2	1 (Urban)	0	0	0	5	5	0	0	0	0	0	0	0	0.5	100	Urban
3	2 (Urban)	3	0	1	0	1	0	1	0	0	0	0	0	0.6666667	5	Urban
4	3 (Urban)	1	2	4	0	2	1	0	1	0	0	0	0	0.7768595	10	Urban
5	4 (Woodland)	0	0	0	0	0	0	0	1	1	0	0	0	0.5	5	Woodland
6	5 (Woodland)	0	1	0	0	0	0	0	0	0	0	0	0	0	10	Woodland
7	6 (Woodland)	1	3	2	0	0	0	1	0	0	1	0	0	0.75	10	Woodland
8	7 (Grassland)	4	3	3	0	0	0	0	0	0	0	1	1	0.75	5	Grassland
9	8 (Grassland)	2	2	0	0	0	0	0	0	4	0	0	0	0.625	10	Grassland
10	9 (Grassland)	4	2	1	0	0	0	0	1	0	0	1	0	0.7160494	10	Grassland

Appendix 2 – R Studio Code for Simpsons Diversity Index

```
Library(vegan)

#Simpson

library(readxl)
Data_Collection <- read_excel("Data Collection.xlsx",
                              sheet = "Sheet2", range = "A1:M10")
View(Data_Collection)
dc <- data.frame(Data_Collection, row.names=1)
InvertSimp <- diversity(dc, index="simpson")
InvertSimp
```

Appendix 3 – R Studio Code for MANOVA

```
library(readxl)
Data_Collection <- read_excel("Data Collection.xlsx",
                              sheet = "Sheet2", range = "N1:P10")
View(Data_Collection)
res.man <- manova(cbind(Turbidity, Diversity) ~ LandUse, data = Data_Collection)
summary(res.man)
summary.aov(res.man)
```

Appendix 4 – R Studio script for regression analysis

```
res.man2 <- aov(Diversity~LandUse, data = Data_Collection)

summary(res.man2)
```

Appendix 5 – Full kit list for manual surveying

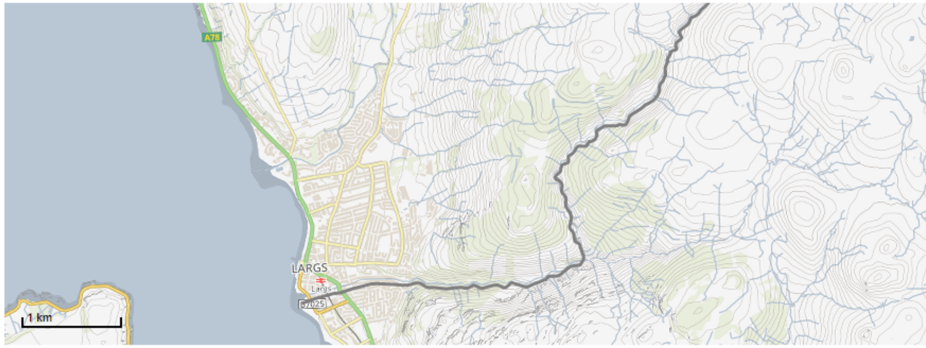
1. Wooden poled net (300mm wide, 500µm mesh)
2. Sample trays (430 x 280 x 75mm) x 5
3. NHBC kick sample ID guide
4. Stopwatch (Garmin Vivoactive)
5. Weather Writer, pen and paper
6. Pipette
7. Wellington boots
8. Turbidity test tube
9. Samsung Galaxy Tablet (with MerginMaps installed and sync’d)
10. Camera (Google Pixel 6)

Appendix 6 – Full hardware/software for spatial analysis

1. HP EliteBook 755 G4 (Windows 10 installed)
2. Google Chrome web browser
3. QGIS v3.36
4. HEC-HMS
5. MerginMaps
6. Microsoft Office Suite
7. Camera (Google Pixel 6)
8. Samsung Galaxy Tablet

Appendix 7 – Gogo Water – SEPA Classification Hub

Gogo Water is a river (ID: 10376), in the North Ayrshire Coastal catchment of the Scotland river basin district. The main stem is approximately 10.0 kilometres in length.



Water classification data for selected water body

ID	Name	Parameter	2022	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009
10376	Gogo Water	1: Overall status	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Poor	Poor	Poor	Poor	Poor
		1-1: Pre-HMWB status	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Poor	Poor	Poor	Poor	Poor
		1-3: Overall ecology	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Poor	Poor	Poor	Poor	Poor
		1-3-1: Physico-Chem	Good	High	High	High	High	High	High	-	Good	High	High	High	High
		1-3-1-1: Temperature	High	High	High	High	High	High	High	High	High	-	High	High	High
		1-3-1-2: Reactive phosphorus	High	High	High	High	High	High	High	Good	Good	-	High	High	High
		1-3-1-4: Dissolved Oxygen	High	High	High	High	High	High	High	High	High	-	High	High	High
		1-3-1-9: Acidity	Good	High	High	High	High	High	High	-	-	-	-	-	
		1-3-1-9-2: pH	Good	High	High	High	High	High	High	High	High	-	High	High	High
		1-3-2: Biological elements	Good	Good	Good	Moderate	Moderate	Moderate	Moderate	Moderate	Poor	Poor	Poor	Poor	Poor
		1-3-2-3: Invertebrate animals	Good	Good	Good	Good	Good	Good	Good	Good	-	High	High	High	High
		1-3-2-3-3: Macroinvertebrates (RiCT/WHPT)	Good	Good	Good	Good	Good	Good	Good	Good	-	High	High	High	High
		1-3-2-3-3-1: Macroinvertebrates (ASPT)	Good	Good	Good	Good	Good	Good	Good	Good	-	High	High	High	High
		1-3-2-3-3-2: Macroinvertebrates (NTAXA)	High	High	High	High	High	High	High	High	-	High	High	High	High
		1-3-2-5: Fish	High	High	High	Moderate	Moderate	Moderate	Moderate	Moderate	Poor	Poor	Poor	Poor	Poor
		1-3-2-5-2: Fish barrier	High	High	High	Moderate	Moderate	Moderate	Moderate	Moderate	Poor	Poor	Poor	Poor	Poor
		1-3-3: Specific pollutants	-	-	-	-	-	-	-	-	-	-	Pass	Pass	Pass
		1-3-3-14: Ammonium	-	-	-	-	-	-	-	-	-	-	Pass	Pass	Pass
		1-3-4: Hydromorphology	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High	High
		1-3-4-1: Morphology	High	High	High	High	High	High	High	High	High	High	High	High	High
		1-3-4-2: Overall hydrology	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High	High
		1-3-4-2-1: Modelled hydrology	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	High	High	-	-	-	
		1-3-4-2-1-1: Hydrology (medium/high flows)	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High	High
		1-3-4-2-1-2: Hydrology (low flows)	High	High	High	High	High	High	High	High	High	High	High	High	High
		4-1: Water quality	Good	Good	Good	Good	Good	Good	Good	Good	Good	-	-	-	