Supporting Citizen Science

Technical Advisory Framework

Version 1, March 2025

Environment Agency

Introduction

The Environment Agency is working with partners to develop tools, guidance and frameworks to support a standardised and connected approach to citizen science monitoring of the water environment.

This technical advisory framework, co-produced with the citizen science community has been designed to help individuals and groups to develop new, or review existing, citizen science monitoring programmes to meets their needs.

Version 1 of the framework focuses primarily on water quality and quantity, with an emphasis on freshwater (rivers and lakes) with additional information about estuarine and coastal waters to follow in version 2 expected in 2025.

What is the purpose of citizen science

Citizen science involves public participation and collaboration in all aspects of scientific research. It can be adapted and applied to diverse situations and disciplines, encompassing a wide range of approaches:

- **Across different scales:** from national continuous projects to focused local studies, or short bursts of activity to those repeated over a longer timescale.
- **With differing skills requirements:** ranging from those requiring no prior knowledge or training, to those requiring training and specialist knowledge.
- **To achieve a wide range of aims:** from measuring environmental and societal change, spatial mapping of objects and features, and many more.

Chilterns Chalk Stream Project carrying out a survey on the River Chess

Image credit: Chilterns Chalk Stream Project

Why is this framework needed?

No single organisation is responsible for collecting all the data needed to protect and manage the environment effectively. Telling an engaging, informative story that drives action relies on interweaving multiple strands of data and observations.

Citizen science offers a valuable opportunity for the Environment Agency (EA) to engage communities in scientific research, data collection, and local decision-making, building stronger relationships with communities and stakeholders through shared goals.

Participation in citizen science, and public interest in monitoring and improving the local environment is increasing. This groundswell of support is encouraging and inspiring, however with limited resources, we cannot support all initiatives or use all data collected by citizen scientists, we need to prioritise on a case-by-case basis. This framework and our advisory role with other stakeholders aims to support well-designed citizen science monitoring initiatives with embedded quality assurance measures to allow us and others to use the data and information to understand the environment and assess the actions needed to improve it.

How to use this framework

This framework is divided into eight key principles which form a structured approach to guide volunteers, coordinators, and stakeholders through the process of planning, conducting, and utilising citizen science monitoring projects. It outlines the steps needed to ensure that the data collected is consistent, high-quality, and meaningful.

We recommend working through the key principles in this framework with your catchment partnership, citizen science community, or other local partners to benefit from their collective knowledge, experience, and skills. This framework should be used as a monitoring pathway and continuously revisited and reviewed.

By following these principles, and using the linked guidance and information within, we hope that citizen science initiatives will become more meaningful and useful for you and others.

Given the widening motivations for participating in citizen science, we are not recommending specific equipment, methodologies or initiatives within this framework.

We will update this framework over time to reflect changes in our understanding, priorities and advances in monitoring technology and methodology, and will continue to engage with the citizen science community as updates are prepared and published.

Where to start - understanding the purpose and the outcome

The first four principles in this framework have been designed to help you to plan the monitoring you will be carrying out.

Before you begin planning, you should spend some time thinking about what is it that you want to achieve by participating in citizen science. For example:

- To participate in a one-off activity which requires no training or previous knowledge.
- An opportunity to meet new people and be part of a community
- An opportunity to learn skills and commit to getting involved more regularly.
- Or if you are already involved, perhaps you are interested in further developing your skills.

Or if you are a volunteer coordinator, community group leader or other stakeholder planning on developing a citizen science initiative, consider what it is you plan to achieve through citizen science monitoring. For example:

- What information you would like to collect?
- Why is this information needed?
- Is citizen science the right approach?

Once you establish what you want to achieve, you can work through the principles to plan an effective approach and develop a collaborative monitoring plan.

Guidance from others to consider

- UK Environmental Observation Framework guide to citizen science
- UKCEH and SEPA- choosing and using citizen science
- Ten Principles of Citizen Science – European Citizen Science Association (ECSA)

Kick sampling nets used as part of a SmartRivers training day

If you have any feedback or suggestions on the Technical Advisory Frame work you can fill out our short survey.

Collaborative Monitoring Plans

The eight principles of this framework have been developed and informed by existing guidance on environmental monitoring and planning:

- Monitoring Guidance | the River Restoration Centre
- UKEOF unifying principles for environmental monitoring | UKEOF

Each of the principles will provide support and direction to help you to develop a well-structured collaborative monitoring plan which has consistent, reliable, and robust monitoring, while remaining accessible and useful to volunteers and partners of varying skill levels.

The Catchment System Thinking Cooperative (CaSTCo) have produced clear guidance on collaborative monitoring plans and templates for you to use. The guidance from CaSTCo and the eight principles of this framework will encourage you to consider:

- Why monitoring and data collection is needed.
- Where to monitor
- When to monitor
- How to monitor
- How to use your data to maximise impact

See guidance from CaSTCo- Collaborative Monitoring Plan

Before developing your plan and working through the framework consider:

- Biosecurity measures to minimise and prevent the spread of Invasive Non-Native Species- Check Clean Dry Protocol » Non Native Species Secretariat
- Safe use and disposal of reagents and consumables and following the waste hierarchy of reduce, reuse and recycle. See links below for case study and webinar which can provide tips on ways to reduce avoidable plastics in laboratories and monitoring
    - Laboratory Plastics Case Study - Preventing Plastic Pollution

Riverfly volunteer training

Key principles for citizen science monitoring

What are the principles & why is it important to consider them

By following these principles, you'll ensure that your monitoring efforts are not only scientifically robust but also meaningful and impactful for your community and the broader scientific community.

Each principle in this pathway helps you to navigate the complexities of citizen science monitoring, from connecting with local partners to sharing your findings in accessible and engaging ways.

Follow the links for more information:

1. **Connect and collaborate:** Work in partnership to achieve common goals.
2. **Build on and learn from existing monitoring:** Explore what, where and how others are monitoring in your local area to inform your monitoring plan.
3. **Define the purpose:** Clearly define the objectives and goals of your individual participation, planned citizen science initiative or monitoring programme.
4. **Develop a well-designed monitoring plan:** Set appropriate level and accuracy of monitoring design to meet project objectives.
5. **Follow quality control measures:** Ensure all processes meet established standards of quality and include evidence of training, calibration and validation steps in the monitoring plan.
6. **Interpret and understand your findings:** Explore the interactions between parameters measured to understand the health of your local waterbody.
7. **Communicate and share outcomes:** Maximise the impact of your results by sharing outcomes in accessible, FAIR and visual way with relevant stakeholders.
8. **Apply outputs to actions:** Use the results to inform action and environmental improvement.

1. Connect and collaborate

Work in partnership to achieve common goals

Why is this important?

Citizen science involves collaboration with and learning from others, including local environmental groups, catchment partnerships, and other citizen science projects.

Identifying and connecting with local stakeholders will help you to identify shared objectives and provide opportunities to work together for cooperative monitoring. This may also help you identify locations or environmental pressures that would be more beneficial to monitor than others.

Citizen science initiatives should be led by the organisation that is best suited to deliver citizen science. This isn't always the EA, although we often provide support through funding and technical expertise we will always aim to work with and through our partners.

How can I find out more?

Find out which catchment you are located in:

- Catchment Data Explorer

Get in touch with your local catchment partnership

- Home – Catchment Based Approach (CABA)
- Catchment Partnership Pages | Catchment Data Explorer

Contact your local university to find out about current and future projects and opportunities to collaborate.

Return to key principles

2. Build on and learn from existing monitoring

Explore what, where and how others are monitoring in your local area to inform your monitoring plan

Why is this important?

Finding out where and what others monitor can help you to understand what data is already available that you can benefit from, as well as identify gaps or opportunities to complement these data and prioritise monitoring methods and locations.

How can I find out more?

We recommend getting in touch with your local catchment partnership to find out what citizen science and environmental monitoring may already be happening in your local area.

- Home – Catchment Based Approach (CaBA)
- Catchment Partnership Pages | Catchment Data Explorer

Explore what and where the Environment Agency monitor

The Environment Agency's environmental monitoring data is open to the public, and accessible through the Defra data portal and signposted through the Environment Agency's Water Hub. Site locations and results can be visualised on the River Basin Management Plan maps.

Data within each explorer is also accessible through Application Programming Interface (APIs), programming language which provides access to the raw data visualised in these apps. Watch this video to find out more: What is an API?

- Defra Data Services Platform
- Water Data Explorer | Engage Environment Agency
- River Basin Management Plan: maps

Environment Agency data can support your monitoring plan by:

- Informing site selection
- Providing reference conditions
- Providing complementary and background data
- Providing baseline information

Further information on what the Environment Agency monitors, tools to access and interpret this data, and links to useful plans and reports are outlined in Table 2.

Explore where and what other national citizen science programmes currently monitor:

Table 1. Examples of freshwater and coastal citizen science monitoring programmes and national monitoring 'blitzes'- intense monitoring across a short period of time, in England:

Monitoring Initiative	Lead organisation	Water type	Duration of monitoring	Link to source
Riverfly Monitoring Initiative (RMI)	Riverfly partnership	Freshwater	Regular monitoring- weekly/monthly	Riverfly Data
SmartRivers	Wildfish	Freshwater	Spring and Autumn	SmartRivers | Scientifically Robust Citizen Science | Wildfish
Freshwater Watch	Earthwatch	Freshwater	Regular monitoring- weekly/monthly	Explore our data | Freshwater Watch
Angling Trust Water Quality Monitoring Network	Angling Trust	Freshwater	Regular monitoring- weekly/monthly	Epicollect5 - Water Quality Monitoring Network
MoRPh Rivers	Modular River Survey	Freshwater Habitat	Occasional	MoRPh Rivers – Modular River Survey
Surfers Against Sewage- Recreational Water Quality	Surfers Against Sewage	Recreational Waters- Coastal and Inland	Regular monitoring- weekly/monthly	Citizen science results - Surfers Against Sewage • Data HQ
Big Seaweed Search	Natural History Museum	Marine/Coastal	Occasional	Big Seaweed Search | Natural History Museum
Shoresearch	The Wildlife Trust	Marine/Coastal	Occasional	Shoresearch | The Wildlife Trusts
The Big River Watch	The Rivers Trust	Freshwater	Spring and Autumn Waterblitz over a weekend	The Big River Watch Data Dashboard | The Rivers Trust
Great UK Waterblitz	Earthwatch	Freshwater	Spring and Autumn Waterblitz over a weekend	Great UK WaterBlitz Results | FreshWater Watch

Box 1. Case Study: Smarter Waters – River Chess- Tier 2

The River Chess Smarter Water Catchment project has used a series of complementary monitoring techniques to understand the issues and monitor any actions to restore this chalk stream catchment. This has involved partners from statutory agencies, non-governmental organisations, water companies and academic institutions, with an emphasis on working with communities and citizen science throughout.

Monitoring has included maintaining a set of continuous monitoring sondes measuring water quality, Mud Spotter surveys in wet weather alongside sediment fingerprinting to trace the sources of sediment, testing of emerging chemicals, before and after restoration habitat surveys using MoRPh, flow monitoring, water vole populations as well as extensive Riverfly surveys.

Using a combination of techniques from both citizen scientists and science professionals has enabled a greater depth of understanding both spatially and over time, increasing confidence in where investment is needed to improve river condition.

This has been run alongside the 'Tracking the Impact' project which focuses on the terrestrial species living in this catchment: breeding birds, butterflies and plants. Recognising the importance of the surrounding landscape as part of the whole catchment ecosystem.

How are we using this information:

- Volunteer flow monitoring is plugged into our database and directly used by hydrometry teams to fill in spatial and temporal gaps.
- Geomorphology teams are advising on sediment fingerprinting and feeding into restoration plans and fisheries work.
- Riverfly data is providing greater understanding of where populations of invertebrates are across catchments (including invasives). The discovery of the winterbourne stonefly by Riverfly volunteers at the top of the Chess has driven EA intermittent stream monitoring programme across the chalk.

For more information follow these links to the website and video case study:

- Citizen Science | R Chess catchment | Smarter Water Catchment
- Chiltern Chalk Stream Project | The Ripple Effect

Explore data from others which may be useful:

- National Storm Overflow Hub for England
- UK Water Resources Portal
- National Network of Regional Coastal Monitoring Programmes

Volunteers from Chilterns Chalk Stream project carrying out a contaminants survey on the River Chess

Image credit: Chilterns Chalk Stream Project

Table 2. Examples of Open Access Environment Agency monitoring data, reports and plans.

Type of data	What it covers	How it can be viewed	Where to access this information	Parameters/indices measured or category of data available	Further information
Macroinvertebrates, aquatic plants & fish data	Datasets of benthic macroinvertebrates, macrophytes (aquatic plants), and fish from surveys for river and tidal freshwaters. These include species lists, abundances, biotic indices and site data.	Datasets can be viewed online and/or bulk downloaded	Ecology & Fish Data Explorer	Average Score Per Taxa (ASPT), Biological Monitoring Working Party (BMWP), Whalley, Hawkes Paisley & Trigg (WHPT), River Macrophyte Nutrient Index (RMNI), Individual Taxa records Rivers (uktag): Invertebrates, macrophytes, fish Lakes (uktag): Macrophytes	The different types of fish monitoring – Creating a better place Cardiff University Invertebrates Study Find out what we discovered on one of our freshwater plant surveys A day in the life – plant surveying on the River Mimram – Creating a better place How to use data explorer
Hydrometric data	Dataset on river levels & flow, rainfall, groundwater and continuous water quality measurements (sondes).	Datasets can be viewed online and/or bulk downloaded	Hydrology Data Explorer	River level/ Groundwater level Daily mean river flow Daily rainfall Dissolved oxygen (% saturation) Long term daily flow records Temperature	Hydrology Data Explorer Making river, rainfall and groundwater data available
River Habitat	Dataset on River Habitat Surveys which include data on the physical character and quality of river habitats across the UK.	Dataset must be downloaded to view the data	River Habitat Survey – Survey Details and Summary Results	Channel form Bankside vegetation Weirs/sluices, culverts, outfalls/ intakes, dams, abstractions, hydroelectric power Habitat Quality Assessment (HQA) Habitat Modification Score (HMS)	

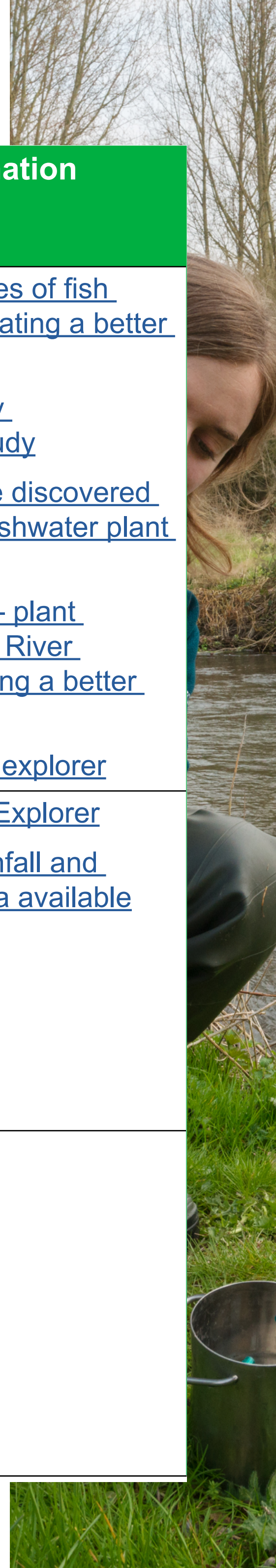


Table 2.continued

Water quality	Datasets of water quality measurements (physico-chemical & specific chemical pollutants) taken from sampling points around the country and analysed in a laboratory.	Datasets can be viewed online and/or bulk downloaded	Explore water quality sites Download water quality data	Ammonia, ammonium, dissolved oxygen saturation, electrical conductivity, orthophosphate, pH, water temperature, turbidity Metals, inorganic chemicals, organic chemicals.	How we test water quality What is a chemistry sample and why does the Environment Agency do them? – Creating a better place Focus on Phosphorus in the Wye
Marine Plans	Find marine planning information for England, including data on marine licenses, environmental designations and policy information from regional marine plans.	Data and information can be viewed online	Explore marine plans	Marine licences Species data Designations and Protected Areas Aquaculture and essential fish habitat Ports, harbours, shipping and recreational areas	Explore marine plans guidance- video
Bathing Waters	Users can look up designated bathing water sites by name or location. Water quality is currently assessed by the Environment Agency from May to September, assessments measure current water quality are available, and at a number of sites daily pollution risk forecasts are issued.	Datasets can be viewed online and/or bulk downloaded	Find a bathing water Bathing waters data	Escherichia coli or E. coli (EC) Intestinal enterococci (IE)	How the Environment Agency monitors and tests bathing water quality – Creating a better place How does the Environment Agency check bathing water quality? Bathing water quality glossary Bathing Water Quality

Table 2.continued

Geographic information	Interactive mapping providing geographic information about the natural environment from across government, covering rural, urban, coastal and marine environments across Great Britain.	Information is viewed online and can be downloaded either directly or through an external website	Magic Map Application	Land based and marine protected sites and designations Landscape classification Habitat classification Geology and soils Administrative boundaries Access Ordinance Survey background mapping	MAGIC Help
Agricultural Land Environmental Risk and Opportunity Tool A.L.E.R.T.	The Agricultural Land Environmental Risk and Opportunity Tool (ALERT) is an online Earth Observation mapping system produced by the Environment Agency in collaboration with Catchment Sensitive Farming (CSF). It enables partners to analyse the rural landscape and target local interventions to reduce pollution from agricultre.	Information is viewed online	ALERT map	Hydrology layers Land use and soil layers Slope threshold layers Topography data (LIDAR) layers Satellite imagery layers Urban layer and road layers	Support for ALERT

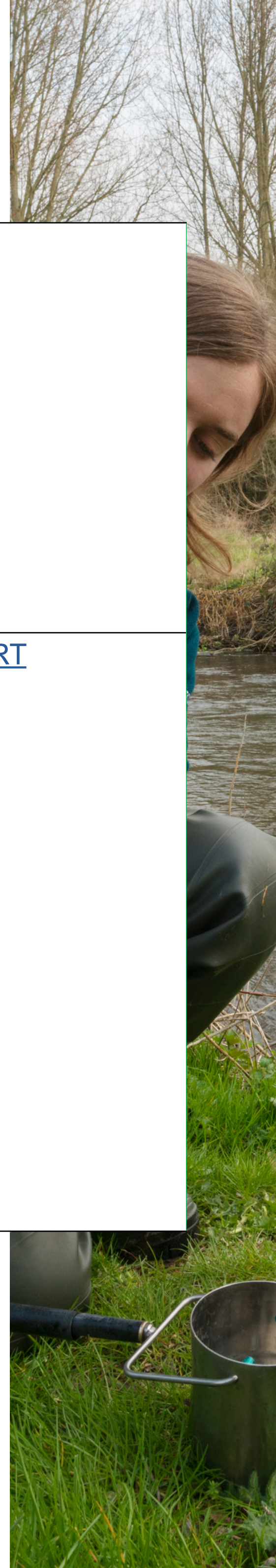


Table 2.continued

Catchment Data Explorer	Allow users to download information about the water environment used in river basin management plans. These include catchment Water Framework Directive classifications, associated objectives and measures.	Datasets can be viewed online and/or bulk downloaded	[Catchment Data Explorer]()	River Basin Management Plans Classifications Surface water chemical classifications Objectives and predicted outcomes Challenges Protected Areas Chemical Status	[Water body data update August 2023 – Creating a better place]() [How to use Catchment Data Explorer]()
Shoreline Management Plans	Shoreline Management Plans (SMPs) identify the most sustainable approach for managing the risk from coastal flooding and erosion over the short (0 to 20 years), medium (20 to 50 years) and long (50 to 100) term. Local authorities and the Environment Agency have led the development of these plans, working together in regional Coastal Groups.	Action plans and reports can be downloaded	[Home | Shoreline Management Plans]()	Evidence on how the shoreline has changed and may change in future Information on the risks from flooding and erosion to people and the developed, historic and natural environment within the SMP area	[The coast is clear: strengthening shoreline management planning – Creating a better place]()

Return to key principles

3. Define purpose

Clearly define the objectives and goals of your individual participation, planned citizen science initiative or monitoring programme

Why is this important?

To maximise the impact of your monitoring, you should be outcome driven. Setting clear and realistic project objectives, agreed by all those involved will help direct your monitoring plan and ensure data collected is relevant and impactful.

When considering the intended outcomes for your project consider:

- The skills, motivation, accessibility needs, and level of commitment of volunteers/ local community
- Recruitment, recognition and retention of volunteers.
- Realistic timescales to allow for contingency planning and meet length and restrictions of funding

Figure 1 illustrates how you might consider the balance between time and effort required. For example, if you are planning an intense monitoring programme over a short period of time this would be an example of a blitz with short time frame and low effort, compared to high level of investment in monitoring equipment and training such as the River Chess in Box 1 would be longer time frame and high effort.

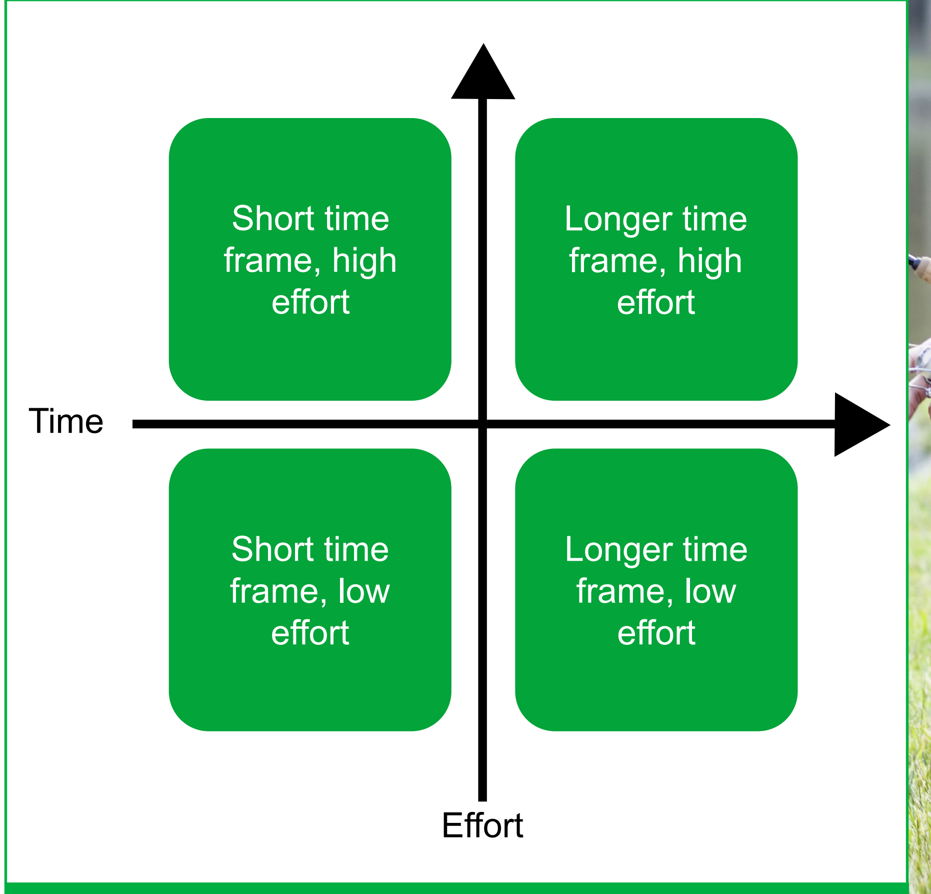
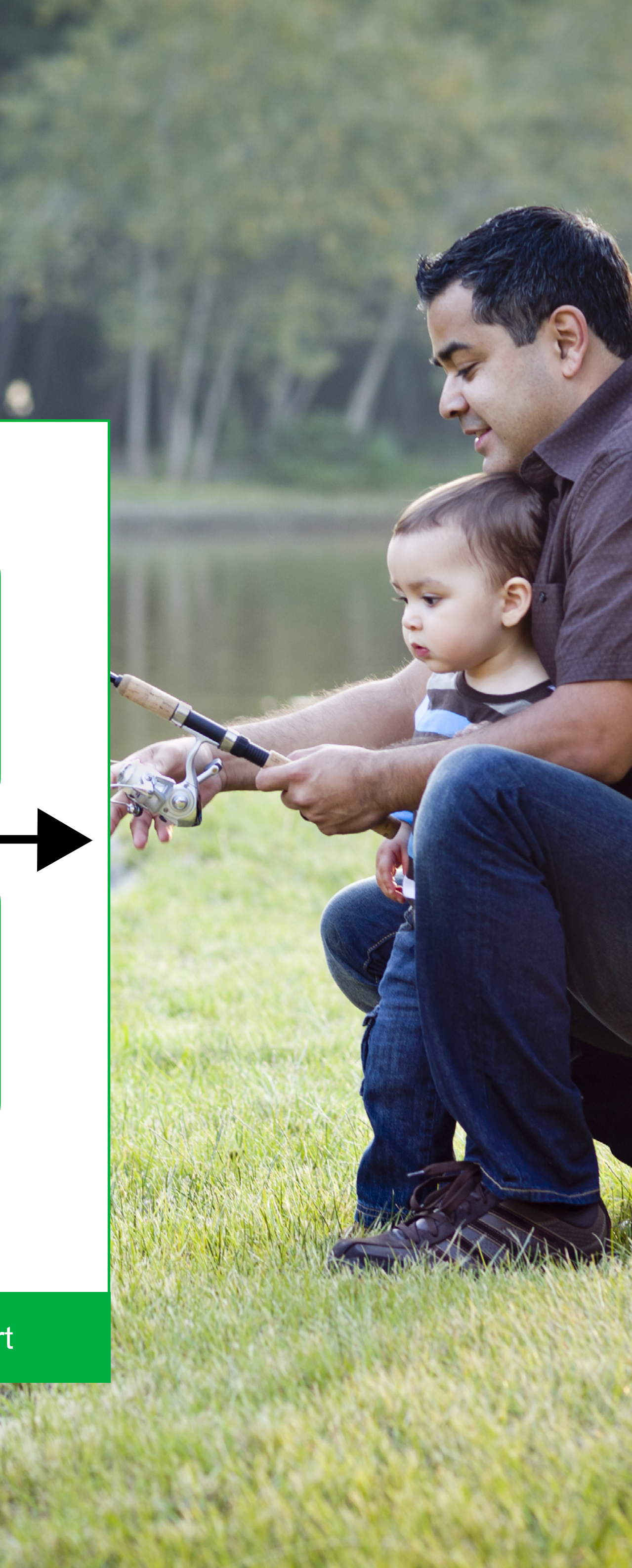


Figure 1: Balance between investment in time and effort

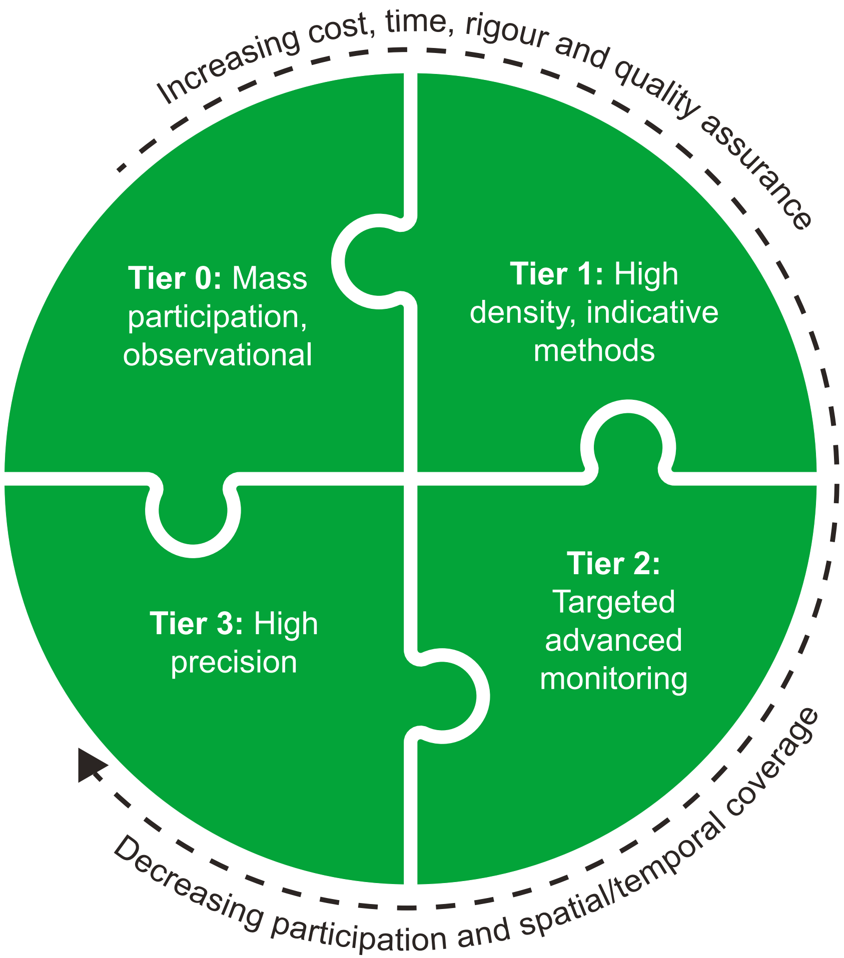


In collaboration with CaSTCo and other environmental non-government organisations (eNGOs), we have developed a 4-tier approach to help categorise and identify which methods and initiatives may be most suitable to meet your needs and project objectives, This approach encourages you to consider the level of investment required in cost, time and skills development, and balance this with the differing levels of resulting data quality and quantity.

Deciding on an appropriate tier at the start of project planning will help inform your monitoring plan and provide clarity when working through the rest of this framework.

Data and information from each tier are extremely valuable and useful, with each tier contributing data to our wider understanding of environmental health, and important information for stakeholders involved in catchment planning.

Further information on how we define each tier and examples across citizen science for bathing water, water quality, biodiversity and water quantity monitoring are outlined in Table 3.



How can I find out more

Setting your primary purpose:

- Guidance: defining your primary monitoring purpose - CaSTCo

Define clear objectives and priority environmental questions:

- Defining your purpose - CaSTCo
- Setting biodiversity monitoring objectives | JNCC Resource Hub

Outline the intended impact of your outcomes, or planned use of data and information collected:

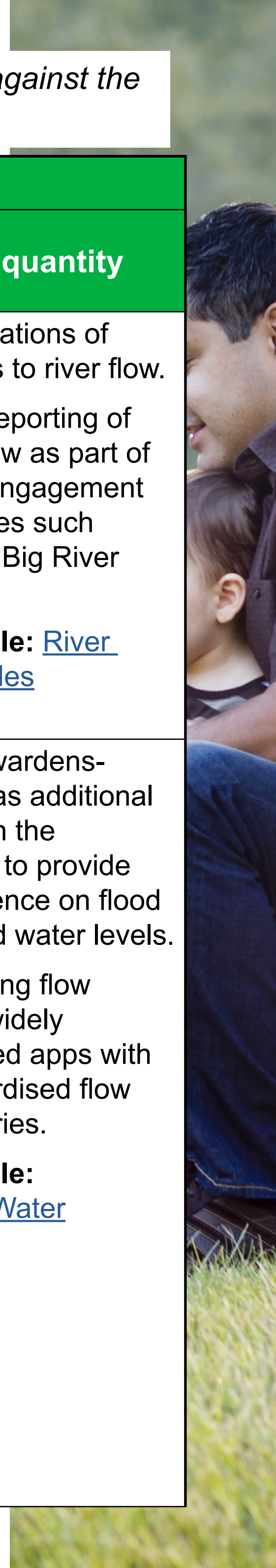
- Measuring Impact of Citizen Science - Indicators
- Making a difference - CaSTCo

If your plan is to conduct a blitz such as The Big River Watch, hosted but The Rivers Trust, the following guidance from CaSTCo will help you plan:

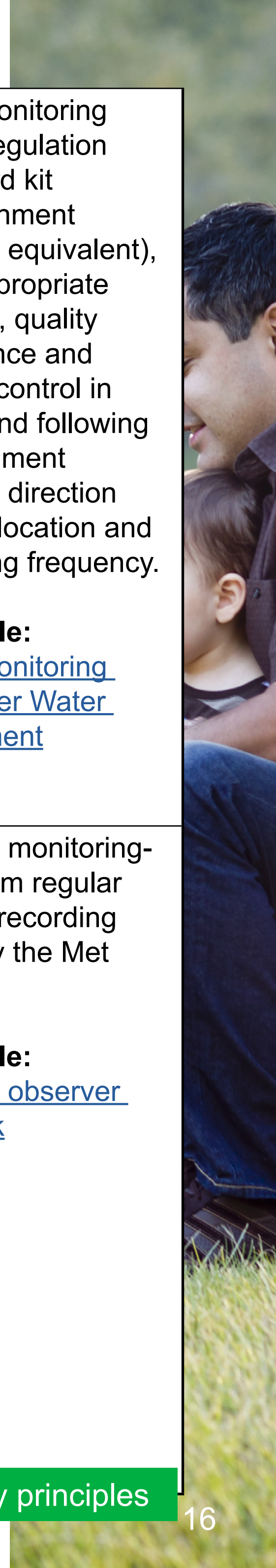
- Guidance: Designing a Water Blitz - CaSTCo
- RiverBlitz review- Ribble Rivers Trust

Table 3. Description and examples of tiers of citizen science monitoring. Activities within this table would generally be characterised against the different tiers as follows, there may be legitimate reasons why future activities wouldn't neatly fit within a particular tier.

Tier	Description	Purpose	Examples of citizen science monitoring			
			Bathing Water investigations	Water quality / Nutrient testing	Biodiversity monitoring	Water quantity
0	High-density, low-resolution data, limited, or no training, previous experience, or equipment required, flexible location and timing. Basic data quality control measures in place.	Broad-scale water surveillance, capturing seasonal snapshots of water quality through mass sampling. Includes anecdotal records and monitoring in response to weather events. Useful for engagement and education.	Observation of bather numbers and weather conditions. Observations of signs of pollution. **Example:** Hello Lamp Post	Observation of water colour, signs of run-off, surface drainage, outfall pipes discharging of sediment in the water. **Example:** The Big River Watch	Incidental or anecdotal records of wildlife on, in or around the water. Angling match-catch records, or records of invasive non native species. **Example:** Invasive Non Native Species Mapper	Observations of barriers to river flow. Basic reporting of river flow as part of wider engagement initiatives such as The Big River Watch. **Example:** River Obstacles
1	Planned and delivered through a lead environmental Non-Government Organisation or academic partner, including volunteer recruitment and management. Basic monitoring equipment used with spatial or temporal focus. Training provided in person or online.	Short-term, high spatial scale or long-term regular catchment monitoring of pollution indicators and to identify environmental pressures. Collect high-density, moderate-resolution data to provide catchment intelligence and complement statutory monitoring.	Monitoring indicators of pollution such as algae, nutrient levels (phosphate, ammonia, nitrates) using test strips or handheld colorimeters. With quality assurance and quality control in place. Monitoring of surface water outfall discharges and indicators of mis-connections in dry weather. **Example:** Severn Citizen science bacteria testing - CaSTCo	Monitoring indicators of pollution such as colour/turbidity of water, pH. Nutrient testing (phosphate, ammonia, nitrates) using test strips or handheld colorimeters. With quality assurance and quality control in place. **Example:** FreshWater Watch	Invertebrate monitoring as part of a wider national initiative with volunteer training, Quality assurance and quality control in place. Can provide early warning signs of pollution and if acted on can prevent further deterioration. **Example:** The Riverfly Partnership	Flood wardens-acting as additional eyes on the ground to provide intelligence on flood risk and water levels. Reporting flow using widely reviewed apps with standardised flow categories. **Example:** CrowdWater



2	Monitoring plan is co-designed with multiple partners to meet monitoring standards, including methodology, sample location, and frequency. Training and equipment provided and approved by lead organisation, academic, stakeholder, or statutory bodies with high levels of quality assurance and control in place, including appropriate limits of detection.	To collect low volume of high-resolution data with significant investment in training, quality control, and assurance. Using high-quality equipment for direct monitoring of pollutants, environmental pressures or monitoring indicators of pollution using enhanced quality control. Data complements statutory monitoring.	This could include laboratory analysis of physio-chemical parameters as indicators of STW discharges. **Example:** iWharfe_report	Direct monitoring of nutrient levels using high specification equipment or equipment calibrated to statutory monitoring equipment. Data could be used as supporting evidence for Reasons for Not Achieving Good Status or to contribute to the Weight of Evidence approach for decision making. **Example:** River Wensum- CaSTCo	Monitoring using a statutory monitoring methodology and following an agreed moderation and quality control- diatom assemblage or macroalgal intertidal monitoring. Data could be used to contribute to Weight of Evidence approach for decision making. **Example:** Community science for healthy coasts	Flow monitoring using regulation standard kit (Environment Agency equivalent), with appropriate training, quality assurance and quality control in place and following Environment Agency direction on site location and sampling frequency. **Example:** Flow monitoring | Smarter Water Catchment
3	Data collected and analysed to professional standards and meets data and monitoring quality control standards gaps with a resilient and robust management system behind it enabling long term continuity of monitoring service	Supplement statutory monitoring to complete spatial and temporal data and evidence gaps.	Direct bacterial load monitored using *in situ* monitoring equipment or samples collected and laboratory analysed by an accredited laboratory using appropriate thresholds. **Examples:** Working towards a cleaner Wharfe The Big Windermere Survey | Freshwater Biological Association	Real-time continuous monitoring with service level agreement for calibration and maintenance and a traceable quality assurance process. **Example:** Water quality sensors | Smarter Water Catchment	Biodiversity citizen science monitoring data uploaded, and quality assured by the National Biodiversity Network is used by the Environment Agency when considering the impacts of planning applications and permits on wildlife. **Example:** Nature Conservation screening in the Environment Agency	Rainfall monitoring- long term regular rainfall recording used by the Met Office. **Example:** Rainfall observer network



Return to key principles

4. Develop a well-designed monitoring plan:

Set appropriate level and accuracy of monitoring design to meet project objectives.

Why is this important?

Once you have agreed on the purpose and objectives of your project, it is essential that you work collectively with your citizen science and monitoring community to set a clear plan of where, when and how you carry out your monitoring to achieve these objectives.

Your monitoring plan should also include information on how you plan to share your findings to maximise impact and use (see principle 7- communicate and share outcomes). This will form the basis of your collaborative monitoring plan.

Box 2. Case Study: iWharfe and EA Bathing Water Investigation- Tier 3

The River Wharfe in Yorkshire has an active and engaged citizen science community which works collaboratively with the EA, catchment partners and academic institutes and operates under the ‘iWharfe’ project banner – largely coordinated by Prof Rick Batterbee & Yorks Dales Rivers Trust (YDRT under the Dales to Vales River Network Catchment Partnership).

Ilkley was designated a bathing water site in Dec 2020 and was the first river site in England designated.

Collaborative monitoring was carried out by the EA and iWharfe citizen scientists to characterise the waterbody from source to confluence and better understand the bacterial loading from various tributaries in the catchment.

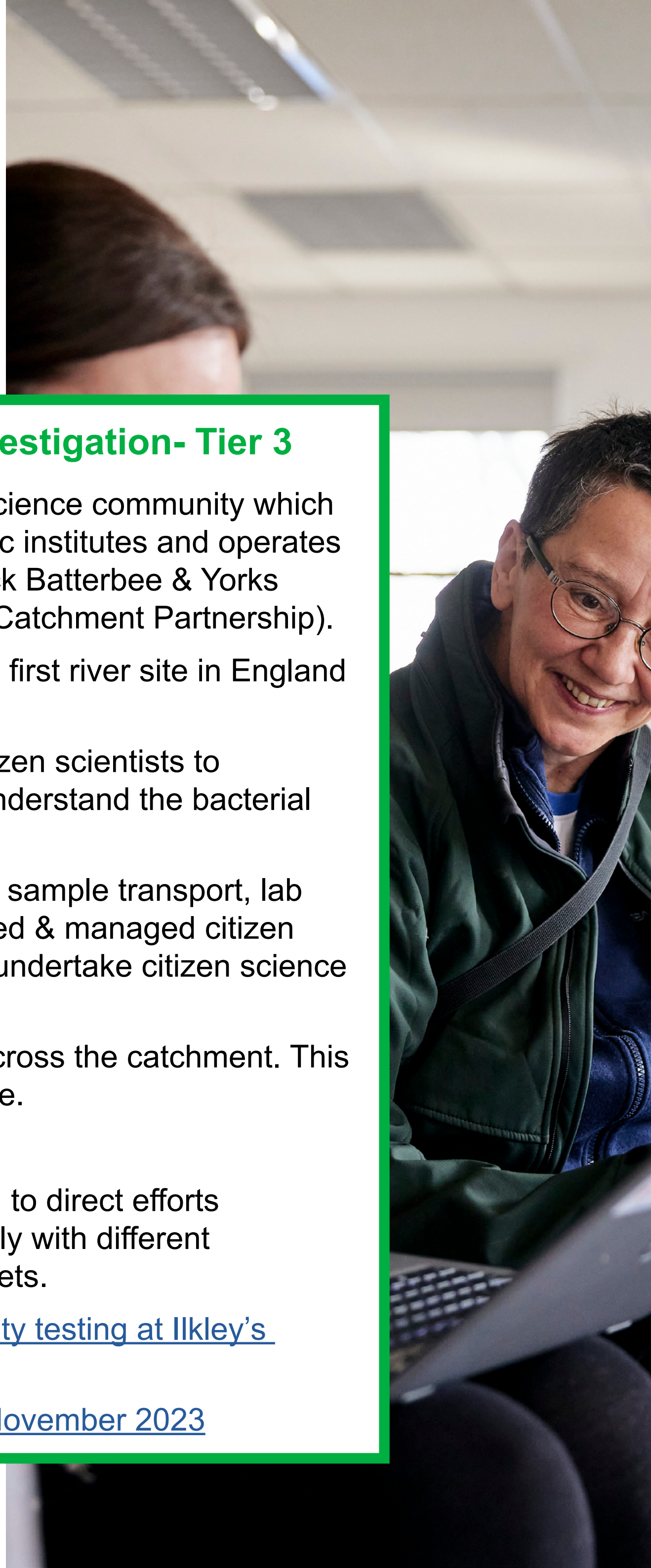
The EA provided technical programme design, logistical support for sample transport, lab analysis of samples & data interpretation. YDRT, recruited, organised & managed citizen scientists’ involvement. Yorkshire Water funded YDRT staff time to undertake citizen science volunteer recruitment and management.

This involved intensive survey across one day to collect samples across the catchment. This level of sampling effort could not be achieved using just EA resource.

How have we used this data:

Samples were sent to the laboratory for analysis and results helped to direct efforts upstream. This case study demonstrates how working collaboratively with different catchment partners can produce these high spatial intensive data sets.

- Working towards a cleaner Wharfe – a closer look at water quality testing at Ilkley’s bathing water – Creating a better place
- The iWharfe Project, a Case Study - A CaSTCo Webinar, 21st November 2023



Where to sample

When devising the number and location of your sampling locations for your monitoring strategy.

Consider:

Volunteer needs:

- Locations should be safe and accessible for all citizen scientists
- Time, commitment and training needs of citizen scientists

Existing monitoring:

- Can additional data be used to supplement your proposed monitoring or inform your sampling points? (see section- build on and learn from existing monitoring)

Sample location:

- Must have permission to access site
- The sites should be representative and appropriate to meet your project objectives
- Some initiatives such as Riverfly will require liaison with the citizen science coordinator or Environment Agency contact to set sampling locations and thresholds for monitoring.
- The EA recommend sampling from 10 river widths downstream of a suspected source of pollution to avoid the mixing zone and collect a representative sample.
- CaSTCo- where will you collect data

Health and safety:

- Setting and following health and safety guidance, which includes volunteer training, safe and legal access to sampling location, and a record of compliance is essential.
- Volunteer management and health and safety compliance should be managed and delivered through the lead partner organisation who hold the duty of care for their volunteers.
  - See example health and safety guidance from CaSTCo
- On the exceptional occasion where volunteer citizen scientists are recruited and working directly with the EA they will be required to follow EA guidance on working with volunteers which will include water safety training and full Personal Protective Equipment (PPE) provision.


Volunteers being trained to carry out a water vole survey

When to sample

When setting the timing and frequency of your monitoring consider:

Volunteer needs:

- Time, commitment and training needs of citizen scientists

Project budget:

- Balance how long and how often to sample with the cost of monitoring and analysing the data to meet your monitoring needs.

Environmental conditions:

- River height and flood warnings
- Weather conditions
- Tidal cycle
- Season

Variation in environmental conditions may influence the physical, chemical and biological characteristics of the waterbody, as well as when the conditions are safe to sample. For example, invertebrate diversity, appearance and extent of ephemeral and intermittent streams, and freshwater sources and springs.

Seasonal sensitive areas:

Be aware of potential disturbance to wildlife including fish which may be more significant at different times of the year. See our blog on closed fishing periods and a user's guide to being river and lake friendly:

- Respecting the coarse fish close season and why we enforce it
- A user's guide to being river and lake friendly

Bathing waters:

If your monitoring plan involves sampling bathing waters, it may be useful to refer to our blog and video which explain how the EA monitors and tests bathing waters, as well as consult the bathing water profiles:

- How the Environment Agency monitors and tests bathing water quality
- How does the Environment Agency check bathing water quality?
- Bathing water quality profiles

Consult further guidance from CaSTCo:

- CaSTCo- when will you collect data?

Box 3. Case Study: Hello Lamp Post- Tier 0

Hello Lamp Post invites local residents and visitors at selected sites across the country to chat to their local beach, river or lake using the Hello Lamp Post artificial intelligence platform.

Those taking part have been able to contribute to citizen science by sharing their own observations from these sites.

The information from these conversations has helped us to understand who visits these sites and how this varies over time. It has also provided us with information on water quality observations and any signs of pollution.

Supporting Citizen Science- Hello Lamp Post Pilot

How to sample

When considering which methods to use, these should be appropriate for the purpose of your monitoring. You should also consider the tiers of methods outlined in Table 3, and the associated quality assurance expectations that are associated with different tiers.

For example:

- Tier 0 may include observations, including photographs and anecdotal information which can be useful to provide additional information in areas we do not currently sample and requires no specific training or equipment.
- Tier 2 or 3 monitoring programmes may include varying levels of quality assurance from calibrated and quality-controlled field samples to quality controlled laboratory analysed data from bathing waters. Depending on the level of quality control these data may complement EA data, providing valuable information in locations and times that are outside of our own monitoring. This can be invaluable to indicate variation in water quality over space and time but will require a higher investment from citizen science in equipment and quality control to meet the standards expected for tier 2 or 3.

We recommend:

- Using existing methodology where possible (see example initiatives in Table 1) which will have quality control in place.
- Following a method audit process for any proposed new methods or kit. Method audits have been carried out to compare selected methods for biological, water quality, physical and soil monitoring through CaSTCo, as well as a framework to follow when carrying out a method audit.
    - Overview: Method audit process - CaSTCo

Further information on the parameters commonly monitored including water chemistry (phosphorus and ammonia) may be useful when decided how to monitor:

- Overview: Phosphorus - CaSTCo
- Ammoniacal nitrogen fact sheet - Appendix 2
- Methods list and categories - CaSTCo

Box 4. Case Study: Bacteria and chemistry water blitz- Tier 2

In the West Midlands the Environment Agency are working with Severn Rivers Trust (lead partners), Severn Trent Water, The Rivers Trust and volunteers to monitor bathing water quality and river health across the Teme catchment as part of CaSTCo.

With a newly designated bathing water at Ludlow, the group are testing different methodologies to monitor water quality and bacteria across the catchment which will provide useful information on potential sources of pollution and reliability of methods and kit.

More information:

- Severn: Citizen science bacteria testing - CaSTCo
- CaSTCo Water blitz comparing bacteria and chemistry methods in the Severn
- CaSTCo Teme data visualisation tool created for open access to data

Return to key principles

5. Follow quality control measures:

Ensure all processes meet established standards of quality and include evidence of training, calibration and validation steps in the monitoring plan.

Why is this important?

Putting measures in place to ensure the methods used for monitoring, data entry and data analysis meet a set of standards will improve the quality of your data and provide you with confidence in your findings. Demonstrating to others that your data has followed a quality assurance process will also improve the trustworthiness and value of your data and information.

The level of quality assurance your monitoring plan follows can be cross referenced to the tiered approach (see Principle 3- Define the purpose and Table 3). This will help us and others assess where the data and information collected from each tier can be used to maximise its impact, ensuring the right data is used for the right purpose.

Quality assurance

This is the process you will apply to check the quality, accuracy, reliability and repeatability of methods used and data produced. This helps provide confidence in data, increasing the weight it can be given in weight of evidence and enabling it to be used for a greater range of purposes.

It should include:

- Process for training new volunteers and refresher training for existing volunteers
- Comparison and cross reference of equipment
- Steps taken to check, maintain and calibrate equipment and reagents used
- Steps to check and clean your data and remove errors

Quality control

Steps to check sample accuracy

- Sample replication and verification
- Blind or random sampling checks

Collecting good quality data is the backbone of any data collection programme. From the start of your project consider the quality of your data.

- Quality Assurance Handbook and Toolkit for Participatory Science Projects | US EPA
- Marine Biological Association- DASSH - Best Practices- Verification and quality control schemes

We recommend the following:

Basic visualisation of your data as a graph or on a map can help you to spot errors that might otherwise be difficult to detect such as errors in site location due to mistakes when entering grid references, or anomalous results that might need to be repeated.

For data to be quality assured, choosing the appropriate and suitable monitoring equipment is essential. Below are some tips to consider when purchasing equipment:

- Does the kit/instrument have any quality certification? This is especially important for test kits
- What is the principle of operation? This must be acceptable to one or more of the accreditation bodies in the EU or North America.
- Are there reagents used? If so, are they safe for non-technical staff or children to handle?
- How often will it need calibrating?
- What is the frequency of maintenance?
- What are the lower and upper limits of detection? For example, many Phosphorus test kits do not detect at the lower limits required.
- What is the accuracy in terms of precision?
- What is the resolution? Some manufacturers state very tight resolution, but this is meaningless if accuracy is not good.
- Is the instrument robust and suitable for field or laboratory use?
- Will the unit cost effective?

Kit demo on the Teme as part of the CaSTCo project

Consistency in recording your data

Data input

- Do not leave blanks- create a consistent format to identify whether a sample was attempted but no data collected.
    - For example, adding a separate tick box for no sample possible, with a notes field to explain why, is good practice. A second tick box for site dry might also be worthwhile in drought prone areas.
    - Do not use zeros to represent no sample taken, zeros should only be used to represent genuine data readings
- Check whether your zeros are genuine data. Understanding the lower limits of your equipment will help to determine this.
    - For example, check the threshold limit of your equipment, some maybe accurate to ± 0.04 (or 5% for higher readings), so a zero is not zero but ≤0.04.

Birmingham River Champions carrying out invertebrate identification

Site locations:

- Be consistent when naming. If a site location changes, use a new site name. If a site location name is updated with more accurate information, please change all instances of that location.
- If using apps to record data these will often give the phone's location and potentially create a new point for each sample. If this is happening, consider how your survey is set up to avoid multiple site references for the same site or repeated visits of the same location or create a exact site names to collate points at each site and give them all the same National Grid Reference.
- Site 'name':
    - Must be unique and in a consistent format.
    - Don't mix A, B, C with 1, 2, 3 and/or 1A, 1B, 1C.
- If using site names that give location information build plenty of capacity into your system. For example, rather than starting 1, 2, 3 as you go downstream then adding the first tributary at 11 consider:
    - 0001 to 0099 as you go downstream
    - 0100 to 0199 for your first tributary etc.
- Site names should not include special characters, punctuation, or brackets as these can cause issues with data upload.

Recording your data digitally

Where possible record data digitally. If using paper forms, ensure data is uploaded to a digital format and this is checked for errors.

Benefits of recording digitally:

- Apps may have inbuilt error checkers to help avoid errors in your data
- Smart phones have inbuilt GPS with an average accuracy of <50m

Disadvantages of recording data digitally:

- Requires all users to have access to smart device or IT
- Risk of no phone/WiFi signal or reduced battery power
- Requires a level of IT literacy and capability

Volunteer training in East Anglia

Box 5. Case study: Ongoing Quality Assurance for Citizen Science in East Anglia- Tier 2

The accuracy of data from trained citizen scientists using digital photometers on the Lark and Wensum was investigated as part of the CaSTCo demonstration catchment activities.

As part of this process a pilot quality assurance process was developed to check consistency in volunteer data accuracy. Colourless phosphate and ammonia standard solutions were provided by The Rivers Trust from a commercial partner and divided into labelled tubes indicating the type of solution but not its concentration. Citizen scientists from the Wensum, Lark, Cam and Waveney tested these standard control samples following their standard testing protocol and results returned to a Quality Assurance lead. A sub sample of each standard was sent to the Environment Agency laboratory for verification.

The results demonstrated that handheld photometer phosphate testing remained broadly accurate, and ammoniacal nitrogen testing still clearly indicates if levels are potentially acutely toxic. Handheld photometer battery level affected accuracy and there was some variation due to temperature in transport and storage because low temperatures result in slower reaction rates. The volunteers who didn’t achieve expected results were approached to check their kit and technique. This work highlighted the following which the citizen science groups have now written into an updated quality assurance process:

- Importance of changing the batteries in handheld photometers on a regular basis
- Testing technique, which could vary for ammonia testing where the manual doesn’t define how reagents should be mixed into the sample
- Temperature needs to be standardised as much as possible

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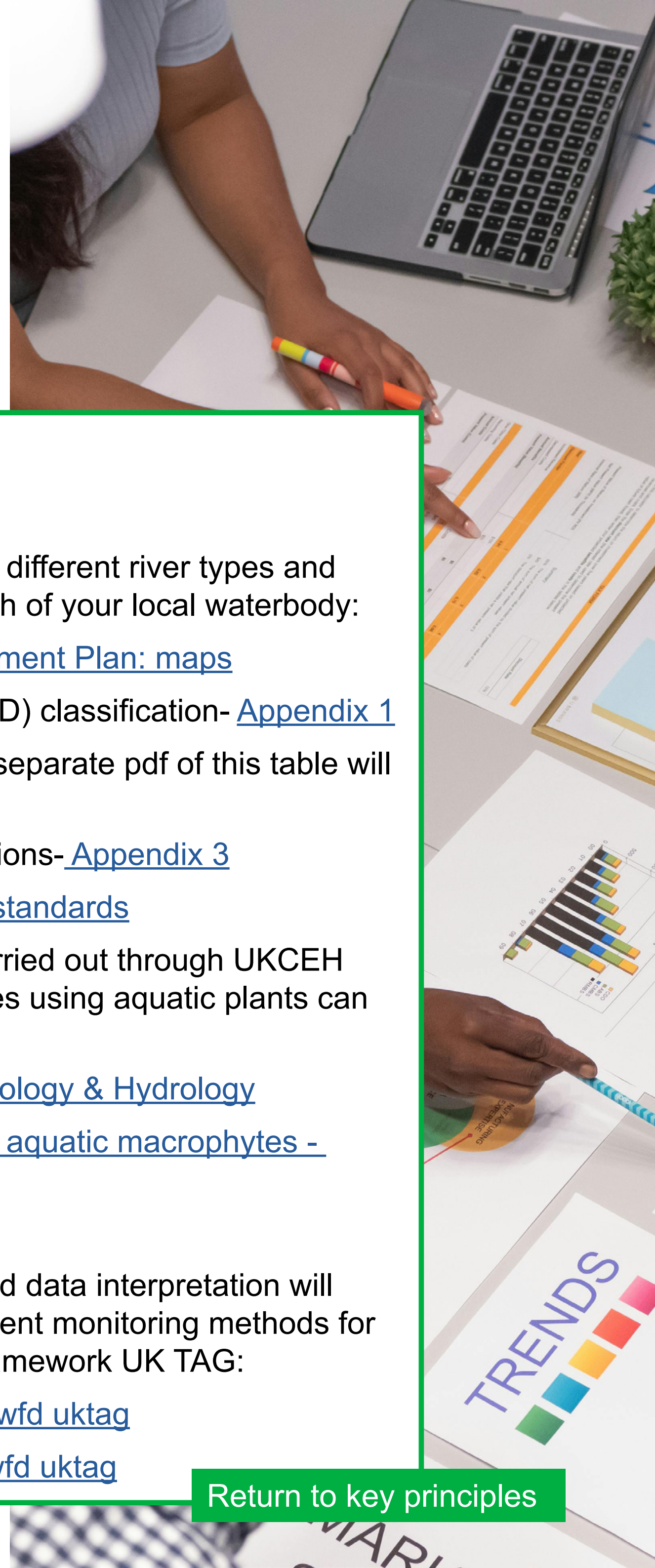
6. Interpret and understand your findings:

Explore the interactions between parameters measured to understand the health of your local waterbody



Why is this important?

It is important to recognise that rivers, estuaries and coastal waters vary naturally in space and time, and parameters monitored in and around your waterbody do not act in isolation but will interact and affect each other.

By collating and analysing the different parameters you have sampled as well as incorporating data from others will help to identify patterns and trends in your data and provide a broader understanding of the health of your waterbody.

Simple visual summaries such as graphs will help to see how your data varies and interacts with each other. Looking for patterns over time and space by mapping or cross referencing to site locations will allow comparison between and within sites and identify spatial changes. However, it is important to recognise that each waterbody and site location will react and respond individually due to the different site specific physical, ecological and chemical characteristics, so be cautious when comparing data from one location to another.

How can I find out more?

Freshwater- Rivers and lakes

Further reference guidance on how to understand different river types and interpret EA data to help you understand the health of your local waterbody:

- River Typology locations: River Basin Management Plan: maps
- River type for Water Framework Directive (WFD) classification- Appendix 1
- General water quality parameter interactions (separate pdf of this table will be uploaded as supplementary info)
- Template for site specific water quality interactions- Appendix 3
- CaBA/CaSTCo- how to calculate site specific standards

More information on long-term lake monitoring carried out through UKCEH and information on ecological classification of lakes using aquatic plants can be found by following the links below:

- Long-term lakes monitoring | UK Centre for Ecology & Hydrology
- The ecological classification of UK lakes using aquatic macrophytes - GOV.UK

Marine

More information to support coastal monitoring and data interpretation will follow in future versions. Below are details on current monitoring methods for coastal and transitional waters from the Water Framework UK TAG:

- Transitional and Coastal Waters - Saltmarsh | wfd uktag
- Coastal Waters – Rocky Shore Macroalgae | wfd uktag

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7. Communicate and share outcomes:

Maximise the impact of your results by sharing outcomes in accessible, FAIR and visual ways with stakeholders

Why is this important?

To maximise the impact of your data once you have collected your data, you should aim to share it. We would recommend you follow an open by default approach and consider options to share your data in both as raw data and in a format which enables others to easily visualise it. This will help other stakeholders to access your data as well as gain insights and maximise its value.

Citizen scientists from the River Brent presenting to an Environment Agency catchment working group

Open by Default

Follow an Open by Default approach to sharing data, making your data accessible to all will maximise the likelihood of its use and the insights gained from a wider range of stakeholders, meaning environmental action can be taken in the right places.

At the Environment Agency, we follow an Open by Default approach to sharing data and publish the vast extent of our data under an Open Government Licence.

- EA blog: Environment Agency data licensing – simpler, easier, faster

Consider advise from others:

- Principles of good data governance - CaSTCo
- Open data in the water industry - Ofwat
- What is 'open data' and why should we care? | The ODI

Visualising yours and others’ data

Visualising your data can help others to understand what data you have collected and where, potentially increasing the impact of your data.

Combining your data alongside other open access data including from other citizen science groups and the EA can be helpful to provide a more comprehensive picture.

Transparency

It is good practice to clearly communicate the following information along with your data. This is termed metadata which provides the user with context or additional information about your data:

- How your data was collected (where, how often, by who)
- Which methods and equipment were used for each data point.
- What quality control processes are in place- see Follow quality control measures

Sensitive data

Personal data is subject to legal protection such as the General Data Protection Regulations (GDPR) and needs to be stored securely and not publicly accessible. It is your responsibility to follow the governments regulation with respect to data sharing and personal data.

You may also have agreements with landowners or decide that publishing certain results publicly without context could result in reputational risks to yourselves or others. Your system should enable access to be restricted where necessary, whilst remaining Open by Default and FAIR.

Box 6. Case Study: Wye Viz data visualisation tool

Various Citizen Science groups within the Wye catchment have formed the Wye Alliance. The Wye Alliance is a collection of groups that follow aligned methodologies when collecting data within the catchment. This collaborative approach helps them combine data, expertise and decision making. Data collected is uploaded to the EPICOLLECT database as one data set, rather than individual data sets. A consistent approach for all Citizen Science groups across the catchment improves accuracy and helps the EA gain a better understanding of the environmental complexities of the catchment.

- For more information on how the EA are working with the Wye Alliance visit: Citizen Science in the Wye | Engage Environment Agency
- To hear more about the WyeViz tool watch this short video: Introduction to WyeViz (the Wye Alliance Citizen Science dashboard)

FAIR Data Principles

Once collected, identifying how your data will be stored, found and re-used by others is essential.

If you are collecting data as part of a national scheme, uploading data to their data portal means much of this work has already been done for you.

Consider:

Storing your data on a platform which has an API (What is an API?), this is a quick way to making your data FAIRer.

We recommend:

- Ensuring your data is findable by all the partners who are involved in the management of your monitoring:
- Make your Catchment Partnership aware of what data you are collecting and where.
    - Home - CaBA
    - Catchment Partnership Pages | Catchment Data Explorer

F

Findable

The first step in (re)using data is to find it. Metadata and data should be easy to find for both humans and computers.

- Ensure your data has metadata associated with it to make it more findable.
- Principles of good data governance- CaSTCo

A

Accessible

Once the user finds the required data, she/he/they need to know how they can be accessed, possibly including authentication and authorisation.

- If your data is stored on a website which require a log-on, your data only accessible to those with log-on credentials- consider whether you want to restrict access to your data

I

Interoperable

The data usually need to be integrated with other data. In addition, the data need to interoperate with applications or workflows for analysis, storage, and processing.

R

Reusable

The ultimate goal of FAIR is to optimise the reuse of data. To achieve this, metadata and data should be well-described so that they can be replicated and/or combined in different settings.

- If your data is only shared in graphs or maps without access to the data behind these visuals this is not reusable.

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8. Apply outputs to actions:

Use the results to inform action and environmental improvement.

Why is this important?

As part of your monitoring, what you will do with your data and how you can use your findings to inform action is essential.

Your results and findings may be important to inform your future monitoring plan, entering back into the planning pathway. Outcomes may inform future sampling locations or additional methods to consider to further improve understanding.

Others will also be interested in your data, this could include the EA, water companies and other water stakeholders.

Your data along with data from others will contribute to a collective evidence base and a more comprehensive picture of environmental health to help inform and prioritise action and decision making. Refer to Principle 1- connect and collaborate

More information from CaSTCo on making a difference: Making a difference - CaSTCo

The EA currently use citizen science data to help:

Improve certainty in our decision making

- For example in our Weight of Evidence Eutrophication tool- see the following webinar for more information: Environment Agency Eutrophication Weight of Evidence Approach
- Working towards a cleaner Wharfe – a closer look at water quality testing at Ilkley's bathing water

Provide additional catchment intelligence

- For example, provide additional information across space and time- see iWharfe example in Box 2.

Support investigations

- For example, see the CaSTCo case study on the River Tat, East Anglia: Citizen science helps resolve pollution issue - CaSTCo

The tiered approach enables us to understand how the data has been collected and the quality control steps taken to improve data quality. We can then use this approach to help us to assess where the data and information collected from each tier can be used to maximise its impact, this ensures the right data is used for the right purpose.

See further examples of how we are currently working with citizen science and the impact of this collaborative working.

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If during your monitoring you identify evidence of pollution, you need to call the EA incident hotline: 0800 80 70 60

The following information may be useful to help determine whether your observations are a result of a natural process or a sign of pollution:

- [What's the foam you sometimes see along Britain's coastlines?]
- [Telling the difference between an algal bloom and sewage]

This framework was developed through collaboration - with thanks to The Rivers Trust and CaSTCo partners, The Riverfly Partnership, Earthwatch, SmartRivers, and all the citizen scientists and water stakeholders that offered advice and suggestions.

If you have any feedback or suggestions on the Technical Advisory Frame work you can fill out our short survey.

Appendix 1

River type for Water Framework Directive (WFD) classification

Rivers vary naturally across England according to their hydrology, geology, biology, chemistry and physical habitat. These five variables combine to create very different rivers in terms of their ecology, and it is essential to factor these variables in, when making informed decisions regarding WFD classification for biological, chemical and physical quality elements.

For example, a mountainous stream in Cumbria can expect a different invertebrate diversity and abundance to that of a lowland chalk stream in Hampshire. A stream in one catchment may have a geology which is different to a stream in neighbouring catchment and therefore we can expect the ecological community to be different. When collecting data to understand a rivers health, it is important to place the data into the context of that river type to support a better understanding of that river's health and the implications for its management.

Ensuring a rivers health is maintained for the effective conservation and/or restoration of the river and its ecology, classification thresholds are essential to help us understand the current and ongoing state of a river health.

River Type			WFD Standards for annual mean Soluble Reactive Phosphorus (mg/L)			
Altitude (metres)	Annual Mean Alkalinity $CaCO_3$ mg/L	Type	High	Good	Moderate	Poor
< 80	< 50	Type 1	0.03	0.05	0.15	0.5
> 80	< 50	Type 2	0.02	0.04	0.15	0.5w
< 80	> 50	Type 3	0.05	0.12	0.25	1
> 80	> 50	Type 4	0.05	0.12	0.25	1

WFD Standards for Ammoniacal Nitrogen (mg/L)				
River Type	High	Good	Moderate	Poor
Upland and Low Alkalinity	0.2	0.3	0.75	1.1
Lowland and High Alkalinity	0.3	0.6	1.1	2.5

Lowland < 80 metres

Upland > 80 metres

High Alkalinity > 50mg/L $CaCO_3$

Low Alkalinity < 50mg/L $CaCO_3$

Site altitude	Alkalinity (Calcium Carbonate - $CaCO_3$) mg/L				
	< 10 mg/L	10-50 mg/L	50 – 100 mg/L	100 – 200 mg/L	> 200mg/L
< 80 metres	Type 1	Type 2	Type 3	Type 5	Type 7
> 80 metres			Type 4	Type 6	

WFD Standards for Dissolved Oxygen Saturation (%)				
River Type	High	Good	Moderate	Poor
Upland and Low Alkalinity and High alkalinity salmonid river	80	75	64	50
Lowland and High Alkalinity	70	60	54	45

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Appendix 2

Ammoniacal nitrogen fact sheet

What is Ammoniacal Nitrogen?

Ammoniacal Nitrogen is the combined measure of two states of inorganic nitrogen ammonia (NH_3) and ammonium (NH_4^+).

Natural Sources of Ammoniacal Nitrogen in Rivers include:

- Decomposition of organic matter
- Excretion from animals

Anthropogenic Sources of Ammoniacal Nitrogen include:

- Raw sewage
- Agricultural run-off (fertilisers and excretion from livestock)
- Industrial processes

Water Framework Directive Thresholds for Ammoniacal Nitrogen in Rivers

WFD Standards for Ammoniacal Nitrogen (mg/L)				
River Type	High	Good	Moderate	Poor
Upland and Low Alkalinity	0.2	0.3	0.75	1.1
Lowland and High Alkalinity	0.3	0.6	1.1	2.5

Lowland < 80 metres

Upland > 80 metres

High Alkalinity > 50mg/L $CaCO_3$

Low Alkalinity < 50mg/L $CaCO_3$

Chemical Name	Also known as
Ammoniacal Nitrogen (NH_4-N)	Total Ammonia; Ammonia Nitrogen
Ammonia (NH_3)	Unionised ammonia, free ammonia, toxic ammonia
Ammonium (NH_4+)	Ionised ammonia, less toxic ammonia

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Appendix 3

Template for site specific water quality interactions

Understanding Water Quality Data and What it means for River Health

Use the following template to collect and record or include from other sources useful information that can help you interpret the health of your river. **Use this template alongside the supplementary information: General water quality parameter interactions.**

Date and Time of Water Sample		Add volunteer data	Add volunteer data
Parameter	Metric	Add site location	Add site location
pH	pH		
Temperature	°C		
Conductivity at 25o C	µS/cm		
Dissolved Oxygen Concentration	mg/L		
Dissolved Oxygen Saturation	%		
Ammoniacal Nitrogen as N	mg/L		
Nitrate as N	mg/L		
Orthophosphate reactive as P	mg/L		

pH (Power of Hydrogen)

- pH describes how acid or alkaline a waterbody is: pH > 7 is alkaline; pH < 7 is acidic.
- Background pH is dependent on local geology.
- Extreme pH can cause ecological problems due to encouraging the formation of toxic ammonia (see ammoniacal nitrogen)
- Photosynthesis removes dissolved CO2 from the water and leads to an increased pH.

Temperature

- Water temperature generally changes with prevailing atmospheric temperature.
- Temperature has a fundamental influence on aquatic organisms, ecological processes and potency of pollutants.
- The ability of water to hold dissolved oxygen reduces as water temperature increases, therefore there is a daily and seasonal pattern observed with this parameter.
- Abrupt changes in the temperature can indicate inputs to a waterbody. For example, when it rains or when effluent is introduced to a river.

Conductivity

- Conductivity measures the total salts dissolved in water by its ability to conduct an electric current.
- Background levels vary depending on the local geology of the catchment.
- Baseline values can range from 100 – 2000 μS/cm.
- Upland streams generally have a lower conductivity, with lowland streams generally having a higher conductivity value as the river receives more minerals from a larger catchment area.
- Changes in conductivity can indicate inputs to a waterbody such as rainfall, industrial and sewage effluent, road run off and gritting run off during winter months.
- Rainfall has a diluting effect on conductivity, lowering the value in μS/cm. However agricultural or road run off following a significant rainfall event will generally increase conductivity levels as run off starts to enter the waterbody.

Dissolved Oxygen Concentration

- Dissolved oxygen concentration is a measure of the amount of oxygen dissolved in the water, expressed in mg/L. Dissolved oxygen is essential for all aquatic life.
- Waterbodies receive oxygen via diffusion from the atmosphere and as a product of photosynthesis from aquatic plants.
- Mixing of the different layers of water within a river, generates turbulence and this increases diffusion of oxygen from the atmosphere to the river. Turbulence is characteristic of rivers in mountainous environments and in lowland streams following a rainfall event.
- Dissolved oxygen concentrations reduce as temperature increases, so dissolved oxygen concentrations are generally lower in summer.
- As pollutants enter a river, bacteria breakdown those pollutants using up greater amounts of dissolved oxygen in the process, reducing the availability of oxygen for aquatic organisms.
- Therefore, with warmer temperatures and less rainfall during the summer months, any pollution entering a river can have a larger impact on the ecology of rivers.

Dissolved Oxygen Saturation

- Dissolved oxygen saturation is a ratio which measures the amount of dissolved oxygen in the water against the maximum amount of oxygen that could be dissolved in the water, at that temperature and pressure.
- The result is expressed as a percentage.
- Waterbodies with a dissolved oxygen saturation > 70% is considered good; < 20% is considered bad.

Nitrate as N

- Nitrate (NO3-) is an essential nutrient for aquatic organisms however excessive amounts from agricultural run-off and sewage effluent can damage the ecology of rivers.
- Bacteria can process ammoniacal nitrogen to nitrate in rivers, when there is sufficient dissolved oxygen in the water.
- Excessive nitrate can cause algal blooms and reductions in dissolved oxygen concentrations.

Ammoniacal Nitrogen

- Ammoniacal Nitrogen is a combined measure of two states of nitrogen dissolved in water: Ammonia (NH3) and Ammonium (NH4+).
- The relative proportion of these two states (ammonia and ammonium) is affected by pH and temperature. An increase in pH or temperature increases the proportion of ammonia (NH3).
- In general, < 10% of total ammonia is in the toxic NH3 form when pH < 8.0. So as the temperature and/or alkalinity of a water body increases, ammoniacal nitrogen becomes particularly toxic to fish and aquatic organisms.
- Ammonium has various sources including excretion from animals (livestock and sewage), decay of organic matter and agricultural fertiliser.
- It is a nutrient necessary for plant and algal growth but excessive amounts in a river can cause a waterbody to become eutrophic causing algal blooms. When algae eventually die, more dissolved oxygen is used by bacteria to breakdown the algae, so there is less dissolved oxygen available in the waterbody for aquatic organisms.

Orthophosphate, reactive as P

- Orthophosphate or dissolved phosphate is the bioavailable form of phosphorus.
- This nutrient, in small concentrations is essential for a healthy freshwater ecosystem as dissolved phosphate is essential for plant and algal growth.
- Excessive amounts derived from fertilisers and sewage discharges can cause eutrophication and reduced dissolved oxygen concentrations.

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