Phase I Climate Change Impact Assessment: Evaluating evidence-based changes in management strategy to steer adaptive responses for mitigating climate change impacts on water quality in Scottish standing waters[1]

If you need more information about this CREW call for capacity building project proposals – please contact MASTS lead Dr Emma Defew (ecd2@st-andrews.ac.uk) with enquiries in the first instance.

Aim & Purpose

The overall aim of Phase I is to produce an evidence-base which addresses the urgent need to assess and understand climate change impacts on the water quality of Scottish standing waters. This evidence-base will be used to inform and serve the collaborative development of mitigation strategies in Phase II for realising impact at multiple scales.

These strategic water research needs will be delivered over two CREW projects termed Phase I (Climate Change Impact Assessment in FY 2021/22) and Phase II (Climate Change Mitigation Strategies in FY 2022/23): Evaluating evidence-based changes in management strategy to steer adaptive responses for mitigating climate change impacts on water quality in Scottish standing waters.

This is a project specification for Phase I [CRW2020/01] expected to commence with the present CREW Facilitation Team (CFT) against the proposed timeline, subject to successful bid at competitive tender. The outputs produced by Phase I will be used to set up Phase II for successful project delivery and strengthen impact of climate mitigation strategies it is expected to create.

Research questions to be answered through this project (please refer to section 1 for more details):

- Is there evidence of a causal link between climate change impacts and water quality issues in Scottish standing waters at national, regional, and local scales?
- What are the main types of climate-driven water quality impacts identified in Scottish standing waters, under current and projected climate change scenarios?
- Which areas, locations, and types of Scottish standing waters are currently most to least at risk in terms of water quality issues from climate change impacts at national, regional, and local scales?
- Which areas, locations, and types of Scottish standing waters will likely experience exacerbated water quality risks under projected climate change scenarios?
- What factors contribute to the risk of water quality issues from climate change impacts in Scottish standing waters at national, regional, and local scales?
- What factors need to be considered for mitigating climate-driven risks to water quality in Scottish standing waters, under current and projected climate change scenarios?

[1] For the purpose of this project proposal Scottish standing waters will include lochs, reservoirs, and other locally important still waters. Using the criteria in Annex 1 of the SSSI site selection guidelines (2018) we would not expect this project scope to cover standing waters which are temporary or less than 1ha in area or 1m in depth (we recognise the value of ponds and pools however they are likely to be functionally and biologically distinctive with different data/evidence/tools available; canals are recognised as important but also excluded from this project scope as they are considered slow moving waters).

Background

Scotland's water environment is facing a climate crisis. This changing climate is already impacting on many standing waters across Scotland in the wake of the warmest decade (2011-2020) on record. There is an urgent need for collaborative environmental leadership to up the scale, pace and impact of fit for purpose climate mitigation strategies to safeguard the integrity, biodiversity, and sustainable use of Scottish standing waters (e.g. for recreation, wellbeing and tourism, water supply and resource management, environmental regulation, and ecosystem functioning) now and in future.

The vision is that through this project Scotland will receive the evidence-base it needs to help steer the formation, prioritisation, and implementation of adaptive responses by key stakeholder organisations, for example through policy-based to nature-based solutions and coordinated management practices, to mitigate climate-driven risks and impacts these could have on the water quality of Scottish standing waters under different climate scenarios.

Previous relevant studies include:

In recent years, algal blooms have become increasingly common in Scottish standing waters due to nutrient enrichment, climate change impacts, and their complex interactions (e.g. warmer surface temperatures, shifts in seasonality and prevailing weather conditions, changes in flushing rate, hydrological extremes, etc.) which may exacerbate the risk of water quality issues. Algal blooms, specifically cyanobacteria (blue green algae or BGA), can reduce the amenity value of these standing waters, increase public health risk, increase water treatment costs, impede statutory environmental objectives from being met within regulatory relevant timescales, impact on biodiversity and the capacity of water managers to deliver water quality improvement targets or maintain effective measures that prevent further deterioration.

Scotland is facing a climate crisis. There is now an urgent need to understand climate-driven risks to water quality and steer changes in the way that Scottish standing waters are currently managed to mitigate climate impacts, under different scenarios. The research questions posed will help to fill those knowledge gaps in Phase I and create mitigation strategies in Phase II.

This is a strategic water research project with specific data/evidence needs to be met at national and regional scales, against a scope which is wider than lochs and will include reservoirs and other locally important still waters. It is anticipated the evidence-base to be produced will include a broad pictorial overview of Scottish standing waters for example from national monitoring networks and relevant area knowledge to well documented local case studies.

Loch Leven may be considered as one example of a Scottish loch-based case study for meeting project needs at the local scale, because climate change impacts are already becoming evident at this site, which has been closely monitored for more than 50 years. For example, its annual average water temperature has risen by >0.3^{o}C per decade over the last 30 years (O'Reilly et al., 2015) and, more recently, there has been a noticeable increase in high intensity rainfall events in the area (May et al., 2017). In addition, successful restoration the loch between 1985 and 2012 has provided a good example of how evidence-based changes in loch and/or catchment management can improve water quality and reduce the likelihood of algal blooms. However, in recent years, climate change impacts have undermined those hard-won benefits. For example, from 2018 (significant year for water scarcity

issues) to 2020 (warmest year on record) the loch developed exceptionally high blooms of cyanobacteria, which led to public access being restricted and amenity value being lost for a prolonged period. These algal blooms also caused the loch to emit an unpleasant odour, causing widespread complaints from visitors and residents. Another possible Scottish loch-based example at local scale is Loch Flemington (e.g. Lang et al., 2016) where a different restoration approach (compared with Loch Leven) was trialled for managing in-lake drivers and symptoms of eutrophication.

It should be noted that another project, Forecasting Risks of Environmental Exacerbation of Dissolved Organic Matter – Building Climate Change Resilience (FREEDOM), has examined climate change risks to water supply, but solely investigates Dissolved Organic Matter. This proposed CREW project is separate in looking at specific water quality issues (nutrient concentrations leading to algal blooms and related impacts e.g. biodiversity, public health, water management, environmental regulation), although it will be able to draw on any appropriate lessons from the FREEDOM project and the predictive model it developed.

Please note that we have not provided an exhaustive list of potential evidence-based examples. We expect the literature review and data collection/analysis in consultation with key project stakeholders to consider relevant available datasets and case studies which could be used to model climate-driven impacts and risk factors in the context of Scottish standing waters.

Some detailed examples of previous relevant studies include:

More than 150 research papers and reports contain information that is relevant to the proposed study, but their content is relatively inaccessible to SNH, SEPA and SW in relation to providing evidence to support their decision making processes. These include:

Carvalho, L., Miller, C., Spears, B.M., Gunn, I.D.M.G., Bennion, H. & May, L. (2012) Water quality of Loch Leven: responses to enrichment, restoration and climate change. *Hydrobiologia* 681: 35-47. https://doi.org/10.1007/s10750-011-0923-x

Defew, L. H. (2008). *The influence of high-flow events on phosphorus delivery to Loch Leven, Scotland, UK*. School of GeoSciences, University of Edinburgh. Ph.D. thesis, 275pp.

Dudley, B., Defew, L. & May, L. (2007) *Elevated phosphorus inputs to Loch Leven during storm events - implications for load estimation and catchment management*. In: Heckrath, Goswin; Rubaek, Gitte H.; Kronvang, Brian, (eds.) Diffuse Phosphorus Loss. Risk assessment, mitigation options and ecological effects in river basins. Aarhus, Denmark, National Environment Research Institute, University of Aarhus, 141-144, 4pp. (DJF Plant Science, 130).

Elliott, J.A. & Defew, L. (2012) Modelling the response of phytoplankton in a shallow lake (Loch Leven, UK) to changes in lake retention time and water temperature. *Hydrobiologia* 681: 105-116. https://doi.org/10.1007/s10750-011-0930-y

May, L. & Spears, B. (2012) Loch Leven: 40 years of scientific research. Understanding the links between pollution, climate change and ecological response. *Developments in Hydrobiology* 218, 130pp

May, L. & Spears, B.M. (2012) Managing ecosystem services at Loch Leven, Scotland, UK: actions, impacts and unintended consequences. *Hydrobiologia* 681: 117-130. https://doi.org/10.1007/s10750-011-0931-x

May, L. (2018) *Water governance at Loch Leven, Scotland*. Unpublished report to the Scottish Government's Rural and Environment Science and Analytical Services (RESAS). 10pp.

May, L., Dick, J., Gunn, I.D.M. & Spears, B. (2019) River Leven Catchment Initiative: Synthesis of current knowledge to help identify environmental management priorities to improve the water environment. CD2018/2. Available online at: crew.ac.uk/publications.

May, L., Moore, A., Woods, H., Bowes, M., Watt, J., Taylor, P. & Pickard, A. (2017) *Loch Leven nutrient load and source apportionment study*. Inverness, Scottish Natural Heritage, 73pp. (Scottish Natural Heritage Commissioned Report no. 962)

O'Reilly, C.M., et al. (2015) Rapid and highly variable warming of lake surface waters around the globe. Geophysical Research Letters 42 (24): 10773-10781. https://doi.org/10.1002/2015GL066235

Lang, P., et al. (2016) Phytoplankton community responses in a shallow lake following lanthanum-bentonite application. Water Research 97 (Special Issue on Geo-engineering to Manage Eutrophication in Lakes): 55-68. https://doi.org/10.1016/j.watres.2016.03.018

Richardson, J., et al. (2019) Response of cyanobacteria and phytoplankton abundance to warming, extreme rainfall events and nutrient enrichment. Global Change Biology 25 (10): 3365-3380. https://doi.org/10.1111/gcb.14701

Please note that we have not provided an exhaustive list of relevant research and references. We expect the literature reviews and consultation with key project stakeholders to consider published research papers, grey literature reports, and relevant policy summaries in the context of Scottish standing waters.

Relevant policy goals, statutory commitments, and policy decisions include:

- EU Habitats Directive
- EU Water Framework Directive
- EU Drinking Water Directive
- Controlled Activities Regulations
- Cyanobacteria (Blue-Green Algae) in Inland and Inshore Waters: Assessment and Minimisation of Risks to Public Health – Scottish Government Revised Guidance 2012
- The Urban Waste Water Treatment (Scotland) Regulations 1994 and The Urban Waste Water Treatment (Scotland) Amendment Regulations 2003
- Perth and Kinross Local Development Plan (adopted Nov 2019), Policy 46: Loch Leven Catchment Area.
- Scottish Government land use strategy policy and future agri-environment support – e.g. Land Use – getting the best from our land: strategy 2021 to 2026; https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/
- Climate Change (Scotland) Act 2009 and Scottish Government Climate Emergency Response Statement

Please note that we have not provided an exhaustive list of specific policy areas. We expect the literature reviews and consultation with key project stakeholders to consider relevant policy and summary documents in the context of Scottish standing waters.

Anticipated impacts of this project are as follows:

- **Overall**: Use of evidence-based changes in management strategy to steer adaptive responses for mitigating climate change impacts on water quality in Scottish standing waters.

The **outputs** from the proposed project will be shared with key stakeholder organisations and used as evidence in Phase II which will inform e.g.:

- **Water Management and Practices:** e.g. Evaluate risks and integrate the evidence-based need to take climate change impacts into account when developing future management strategies for the sustainable use and environmental regulation of water quality in Scottish standing waters.
- **Water Policy and Practice:** e.g. Inform policy:practitioner change such as Land Use Strategy and related agri-environment support to mitigate climate-driven water quality risks.
- **Water and Land Planning:** e.g. Determine whether including phosphorus mitigation in supplementary planning guidance will be effective at reducing the potential impact of housing developments on nearby waterbodies, under different climate change scenarios.
- **Tools and Approaches:** e.g. From existing and innovative policy-based to nature-based solutions what tools are available, and approaches could be created, for practitioners to mitigate the impacts of climate-driven water quality issues (nutrient concentrations leading to algal blooms and related impacts e.g. biodiversity, public health, water management).
- **Support Intended Climate Change Mitigation Outcomes:** e.g. Develop a shared understanding of intended climate change mitigation outcomes to help steer the formation, prioritisation, and implementation of adaptive responses by key stakeholder organisations, for example through policy-based to nature-based solutions and coordinated management practices, to mitigate climate-driven risks and impacts these could have on the water quality of Scottish standing waters, under different climate scenarios.
- **Maximal Benefits:** e.g. Realise the impacts expected to be delivered at multiple scales (e.g. for Policy, People, the Water Environment) from evidence-based project outputs such as key recommendations.
- **The primary beneficiaries** of project outputs will include the Scottish Government (SG), Scottish conservation and regulatory agencies (e.g. NatureScot, SEPA, DWQR), and water managers (e.g. Scottish Water).
- **The secondary beneficiaries** of project outputs will include e.g. the general public, local council authorities (LAs), national park authorities (NPAs), and broader water-related community in Scotland (e.g. SFG Climate Action Team).

Expected improvements for policy, people, and the water environment through project outputs include e.g.:

- **Policy** – e.g. evidence-based changes in management strategy to steer adaptive responses for mitigating climate change impacts will support delivery of statutory goals (e.g. EU Water Framework Directive targets for waterbodies to meet good ecological status as regulated by SEPA; Scottish Government favourable condition targets for protected nature sites as assessed

by NatureScot's Site Condition Monitoring programme) and relevant SG guidance (e.g. advice on possible public health risk from BGA blooms), under different climate scenarios.

- **People** – e.g. evidence-based changes in management strategy to steer adaptive responses for mitigating climate change impacts will support reduced public health risk from climate-driven water quality issues, and improved amenity value (e.g. for recreational and wellbeing benefits) in Scottish standing waters, under different climate scenarios.
- **Water Environment** – e.g. evidence-based changes in management strategy to steer adaptive responses for mitigating climate change impacts will support Scotland's coordinated response to the climate crisis to safeguard the water environment, now and in future.

Please note that we have not provided an exhaustive list of potential outcomes. We expect the literature reviews, data analyses and consultation with key project stakeholders to consider relevance and impact of project outputs in the context of Scottish standing waters.

Project Scope

The overall aim of Phase I is to produce an evidence-base which addresses the urgent need to assess and understand climate change impacts on the water quality of Scottish standing waters. This evidence-base will be used to inform and serve the collaborative development of mitigation strategies in Phase II for realising impact at multiple scales.

It is expected that this project will achieve the above-mentioned aim by carrying out the objectives described in section 1, using inputs described in section 2, in the format described in section 3, and in the timeframe given in section 4, with consideration for intellectual property, data management and risks outlined in section 5 (please also refer to Table 2).

1) Objectives:

- **Objective 1.** Use **Phase I** to establish and deliver a preliminary[2] evidence-base to evaluate the extent to which:

  1.1. Climate change **impacts** are **driving** a current and future **risk** of water quality issues[3] in Scottish standing waters with assessment undertaken at national, regional, and local scales[4].

  1.2. Climate change **impacts** on water quality in Scottish standing waters are mediated through catchment management practices, in-lake processes, and other interacting **factors** (e.g. prevailing weather; hydrological extremes) in current and projected climate change scenarios[5].

- **Objective 2.** Apply expert opinion, best available[6] data, and combined outputs from **Objective 1.** to answer these 6 key strategic water research questions through this project:

  2.1. Drivers and Impacts:
  - Is there evidence of a causal link between climate change impacts and water quality issues in Scottish standing waters at national, regional, and local scales?
  - What are the main types of climate-driven water quality impacts identified in Scottish standing waters, under current and projected climate change scenarios?

  2.2. Risk:
  - Which areas, locations, and types of Scottish standing waters are currently most to least at risk in terms of water quality issues from climate change impacts at national, regional, and local scales?
  - Which areas, locations, and types of Scottish standing waters will likely experience exacerbated water quality risks under projected climate change scenarios?

  2.3. Factors:
  - What factors contribute to the risk of water quality issues from climate change impacts in Scottish standing waters at national, regional, and local scales?
  - What factors need to be considered for mitigating climate-driven risks to water quality in Scottish standing waters, under current and projected climate change scenarios?

[2] SEPA cyber-attack impacts on relevant data/evidence (e.g. Table 2) will need to be mitigated for achieving Phase I objectives and high confidence in the outputs. It is anticipated that most relevant Phase I data needs will be met through publicly accessible/available information, appropriate data sharing/collaboration agreements, engagement with the PSG membership and wider professional networks. There is a strong possibility that data access/availability to the latest advanced digital technology platforms (e.g. satellite and/or remote-sensing water research led by the University of Stirling) will require further discussion and special permissions. This may cost project time to be facilitated. There is limited flexibility to buffer slippage given other data challenges to be confronted within the timeline constraints and therefore could impact on progress. To ensure this work delivers on the specified ask, a desire to 'enhance' Phase I outputs (e.g. for quality or completer bigger picture purposes) may need to be viewed through a pragmatic lens of 'best available' collaborative data and involve making reasonably balanced decisions during the project lifespan. There may be opportunities to gain some traction on data complexities during FY 2021/22, then circle back for evaluating and further strengthening this preliminary evidence-base in Phase II (e.g. when any additional data sharing/collaboration agreements could be set in place).

2) Inputs required:

a) Literature Review and Expert Opinion

b) Data/Evidence Collection and Analysis

c) Extensive GIS Mapping Visualisation

d) Extensive Climate Modelling Scenarios

3) Outputs required:

a) Database (preliminary evidence-base) as described in the preceding sections and Table 1 (DRAFT Delivery Roadmap)

b) Maps[7]

c) A Main Report of max. 30 pages (and no more than 12,000 words) (excluding appendices)[8] that addresses all the outputs as described in the preceding sections and Table 1 (Phase I DRAFT Delivery Roadmap)

d) An Executive Summary (1-2 pages)

e) A Plain English summary[9] of aims and results (1-2 pages) for dissemination purposes

4) Projected timeline (please refer to Table 1 Phase I DRAFT Delivery Roadmap for more details):

[3] For the purpose of this project proposal the water quality issues will focus on climate change interactions with eutrophication drivers (e.g. nutrient concentrations), risks (e.g. symptoms) which include the incidence of algal blooms and related impacts (e.g. biodiversity, public health, water management, environmental regulation), and other contributing factors in Scottish standing waters.

[4] For the purpose of this project proposal the assessment of climate change impacts on water quality of Scottish standing waters includes a broad overview to more focussed evidence-base needs from national (e.g. loch typology, geographic distribution), regional (e.g. catchment-based drivers; climatic variation; inferences from published experimental mesocosm studies), and local (e.g. propensity to form nuisance algal blooms by drawing on available data, knowledge and site-specific case studies) scales.

[5] For the purpose of this project proposal the climate change scenarios can be modelled from 1981-2001 as the baseline, and 2021-2040 as the period of interest, with assessment of current status and future projections for 5-10 yearly intervals up to 20 years.

[6] Drawing on a combination of relevant available data and expertise from key stakeholder organisations; data sharing and/or collaborative agreements; citizen science initiatives; published research papers, grey literature, and policy summaries; and the Scottish Freshwater Group (SFG) Climate Action Team Evidence-base.

[7] For the purpose of this project proposal to visualise where (e.g. geographical distribution; typologies) the water quality of Scottish standing waters will be most to least at risk from climate change impacts as assessed at national, regional, and local scales under current and projected climate scenarios.

[8] Where a report or other type of output produced for CREW is, either ahead of the project being commissioned, or during the lifecycle of the project, deemed to not be viable for public distribution and should be kept confidential to the stakeholders, the research team should provide a 4-page summary that describes the research without touching on confidential issues. This summary will then be posted on the CREW website.

[9] A plain English summary is required for all CREW projects.

Table 1. Phase I DRAFT Delivery Roadmap for Objectives 1 & 2 in FY 2021-22.

Phase I is a standalone CREW capacity building project [CRW2020/01] with a max budget allocation of £70k (incl. VAT) and final CFT completion deadline of 28 Feb 2022. It will be facilitated in two stages termed Part (i) "Inputs" and Part (ii) "Outputs" for achieving key milestones from 1 to 10 set against the overall project constraints.

It is expected that strategic water research outputs delivered from this project work will be used, subject to funding availability and continuity arrangements, to set up Phase II for success in FY 2022/23 and strengthen impact of climate mitigation strategies it is expected to create.

The DRAFT delivery roadmap (Table 1) has been developed to provide a clear steer and as a living project management tool. Resource for Phase I Parts (i) "Inputs" and (ii) "Outputs" will be split approx. 80:20 respectively. It is imperative that this project is completed (i.e. final project outputs submitted) by the end of February 2022 (followed by CFT online publication in March 2022) and as such the CREW Project Manager will work closely with the Research Team/PSG Membership to ensure Objectives 1 and 2 are met against the milestones and timeline established below, and to the agreed maximum budget (£70k incl. VAT).

Milestones	**Expectations**	**Max Budget Provided**	**Max Timeline Provided**
Initial CFT project mobilisation phase & collaborative engagement with key stakeholders	Phase I Scope Development & Finalisation, Tender Call & Review, Procurement Process	-	*ca* early June to late August 2021
Phase I Part (i) "Inputs" DRAFT Delivery Roadmap – Objectives 1 & 2: Establishing the evidence-base and applying expert opinion.			
Milestone	**Expectations**	**Max Budget Provided**	**Max Timeline Provided**
1	Start-up PSG meeting & prep	-	*ca* late Aug to early Sept 2021
2	Best available data/evidence collection & representative analysis • National, regional & local assessment scales • Preliminary GIS mapping visualisation & climate modelling scenarios	-	Sept-Nov 2021

3	Literature review • Basic & grey literature • Relevant policy summaries	-	Sept-Oct 2021
4	1 of 2 Interim PSG meeting & prep (e.g. Discuss updates, and next steps)	-	*ca* early Nov 2021
5	Best available data/evidence collection & representative analysis cont'd • Consider PSG feedback • Extensive GIS mapping visualisation & climate modelling scenarios • Build on draft outputs for Objectives 1 & 2	-	Nov-Dec 2021
6	Facilitate key briefing update & receive comments from PSG (CFT interim deadline of 16 Dec 2021)	-	ca early Dec 2021
		Phase I Part (i) = £56k (incl. VAT)	**CFT interim deadline = 16 Dec 2021**
Phase I Part (ii) "Outputs" DRAFT Delivery Roadmap – Objectives 1 & 2: Delivering the evidence-base and answering 6 key strategic research questions.			
7	Synthesis & expert opinion for draft Objectives 1 & 2 outputs (described in preceding sections)	-	Jan-Feb 2022
8	2 of 2 Interim PSG meeting & prep (e.g. Review of draft Objectives 1 & 2 outputs, and discuss comms & impact /dissemination opportunities)	-	*ca* late Jan 2022
9	PSG review & feedback on near-finalised Objectives 1 & 2 outputs	-	*ca* mid Feb 2022
10	Final PSG meeting & prep (e.g. finalise Objectives 1 & 2 outputs for publication & wider dissemination) (CFT final deadline for submitting the final project outputs is 28 Feb 2022; followed by CFT online publication in March 2022)	-	*ca* end Feb 2022
		Phase I Part (ii) = £14k (incl. VAT)	**CFT final deadline = 28 Feb 2022**

Maximum funding available (incl. VAT): £70,000.

5) Intellectual property, data management & risks:

The project will require water quality and hydrological data sets held by UK CEH, Scottish Water, and SEPA. There are typically no restrictions on access to these datasets. They are freely available for research purposes.

However, access to relevant SEPA monitoring data may be impacted due to the cyber-attack on 24 December 2020. This information may become available within the timescale of this proposed project or it may not, and we need to contingency plan for the latter situation. In the meantime, to help mitigate the potential risk to project delivery and with permission from SEPA, other organisations such as UK CEH and JHI, may be approached to share copies of data that they have licenced from SEPA for use on other projects.

In addition, other sources of data for Scottish standing waters include UK CEH, Scottish Universities and Research Institutes, Scottish Water (reservoirs), Upland Waters Monitoring Network (e.g. for upland lochs), Environmental Change Network (ECN), JHI, Health Protection Scotland epidemiology surveillance records (SEISS), UK CEH Bloomin' Algae Citizen Science App, and the SFG Climate Action Team Evidence-base. Note these data may require permission for use from the data providers, unless prior agreed.

We have signposted some specific examples of data/evidence needed to successfully deliver this project proposal – which includes initial consideration of practical solutions to mitigate potential risk of access/availability challenges specifically related to SEPA cyber-attack impacts and prevent these becoming future showstoppers:

Table 2. Initial scoping of potential data/evidence needs & solutions to help mitigate any SEPA cyber-attack impacts

Example of Data/Evidence Needs	Potential project delivery risk from SEPA cyber-attack impacts? (Y or N)	Potential impact on project delivery (low, medium to high risk)	Example of Feasible Mitigation Measure(s)/ Other Notes
UK Lakes Portal Database held by UK CEH – typologies (e.g. depth, alkalinity, water colour, TP etc.) for national, regional & local scale assessment	N	-	-
SEPA routine monitoring network – WFD assessment of ecological status, cyanobacteria biovolume, Chlorophyll *a* concentration using relevant BQE metrics e.g. PLUTO (or its BGA-based predecessor form)	Y	Preferential order for prioritising Phase I data collection & analysis needs is from national and regional to local scale assessment: **High** (no data and/or data >5 years) which may be reduced to	UK CEH, JHI etc.; phased project delivery & reasonable prioritisation e.g. local case studies, whilst building up a strategic picture of regional & national data/evidence-base

		Medium (some data and/or within 2-5 years) or **Low** (most data and/or <2 years) if best available data/evidence can be sourced	
SEPA routine monitoring network – WFD assessment of specific water physico-chemistry parameters (e.g. nutrient concentrations such as P and N, temperature records)	Y	Preferential order for prioritising Phase I data collection & analysis needs is from national and regional to local scale assessment: **High** (no data and/or data >5 years) which may be reduced to **Medium** (some data and/or within 2-5 years) or **Low** (most data and/or <2 years) if best available data/evidence can be sourced	UK CEH, JHI etc.
SEPA investigative monitoring network – WFD 'equivalent' assessment of ecological status, cyanobacteria biovolume, Chlorophyll *a* concentration using relevant case studies (e.g. Loch Flemington)	Y	Preferential order for prioritising Phase I data collection & analysis needs is from national and regional to local scale assessment: **High** (no data and/or data >5 years) which may be reduced to **Medium** (some data and/or within 2-5 years) or **Low** (most data and/or <2 years) if best available data/evidence can be sourced	UK CEH, Publication(s), relevant PSG members
SEPA investigative monitoring network – specific water physico-chemistry parameters (e.g. nutrient concentrations such as P and N, temperature records) for relevant case	Y	Preferential order for prioritising Phase I data collection & analysis needs is from national and regional to local scale assessment:	UK CEH, Publication(s), relevant PSG members

studies (e.g. Loch Flemington)		**High** (no data and/or data >5 years) which may be reduced to **Medium** (some data and/or within 2-5 years) or **Low** (most data and/or <2 years) if best available data/evidence can be sourced	
SEPA ad hoc monitoring / incident response network – e.g. records of algal bloom incidents in Scottish standing waters	Y	Preferential order for prioritising Phase I data collection & analysis needs is from national and regional to local scale assessment: **High** (no data and/or data >5 years) which may be reduced to **Medium** (some data and/or within 2-5 years) or **Low** (most data and/or <2 years) if best available data/evidence can be sourced	SEISS, UK CEH Bloomin' Algae App, relevant PSG members, Local Authorities / may require some data sharing permissions
SEPA evidential reports – e.g. grey literature	Y	**High** (no literature and/or >5 years) which may be reduced to **Medium** (some literature and/or within 2-5 years) or **Low** (most literature and/or <2 years) if best available data/evidence can be sourced	Publication(s), relevant PSG members, expert literature review
Hydrological and/or Climate data e.g. rainfall, flushing, etc.	N	-	MET, UK CEH, relevant PSG members, etc.
Climate Scenario Models – e.g. GLEON, etc.	N	-	-
Digital technology platforms for water quality monitoring data such as Chlorophyll *a* concentration, water colour, surface temperature etc. –	N	-	- / may require some data sharing permissions

satellites and/or remote sensing (e.g. GLOBOLAKES)			
Scottish Water data e.g. drinking water reservoir data, ad hoc monitoring data	N	-	- / may require some data sharing permissions
NatureScot relevant monitoring data e.g. historical baselines	N	-	-
Relevant CREW project publications	N	-	-
Others e.g. UK CEH e.g. Loch Leven Monitoring Programme; ECN network, UWMN network, SFG Climate Action Team Evidence-base	N	-	-

Please note that we have not provided an exhaustive list of data/evidence needs. The assessment of project delivery risk due to SEPA cyber-attack is provisional at this stage. It will need additional scoping and continually reviewed as/when relevant SEPA data/evidence becomes available. We expect the literature reviews and data collection/analysis in consultation with key project stakeholders to consider relevant data/evidence needs in the context of Scottish standing waters and feasible solutions for helping mitigate any SEPA cyber-attack impacts within the project constraints (e.g. maximum budget, time available) and overall lifespan.