# THE ASSESSMENT OF ENVIRONMENTAL FLOWS FOR THE RIVERS AND STREAMS OF GEORGIA

METHODOLOGY

**USAID GOVERNING FOR GROWTH (G4G) IN GEORGIA**

6 April 2017

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# ACRONYMS

| | |
|---|---|
| AA | Association Agreement |
| CIS | Common Implementation Strategy |
| EF | Environmental Flow |
| EFA | Environmental Flow Assessment |
| EIA | Environmental Impact Assessment |
| EU | European Union |
| FDC | Flow Duration Curve |
| G4G | Governing for Growth in Georgia |
| GES | Good Ecological Status |
| GoG | Government of Georgia |
| GoG | Government of Georgia |
| HMWB | Heavily Modified Water Bodies |
| IHA | Indicators of Hydrological Alteration |
| INRMW | Integrated Natural Resources Management in Watersheds of Georgia Program |
| MENRP | Ministry of Environment and Natural Resources Protection of Georgia |
| NEA | National Environmental Agency |
| NGO | Non-Governmental Organization |
| SEA | Strategic Environmental Assessment |
| SEFA | System for Environmental Flow Analysis |
| USAID | United States Agency for International Development |
| WFD | Water Framework Directive |
| WRM | Water Resource Management |

# CONTENTS

# EXECUTIVE SUMMARY

The Government of Georgia (GoG) has signed an Association Agreement (AA) with the European Union (EU) and is working towards implementation of the Water Framework Directive (WFD). It has therefore elected to align its proposed national methodology and stepwise procedures for establishing environmental flows (EFs) for the rivers and streams within its territory with the broader set of guidance presently in place to support the WFD.

The WFD is aimed at maintaining and improving the quality of aquatic ecosystems in the EU. The WFD, as well as the Birds and Habitats Directives, set binding objectives for the protection and conservation of water-dependent ecosystems. These objectives can only be reached if supporting flow regimes is guaranteed (Common Implementation Strategy (CIS) 2015: Ecological flows in the implementation of the WFD. Guidance Document No. 31. Technical Report - 2015 – 086. European Commission. 108 pp.).

The WFD requires surface water classification through the assessment of ecological status, or ecological potential in the specific case of heavily modified water bodies (HMWB), and surface water chemical status. Three groups of quality elements must be used for the assessment of ecological status/potential, viz.:

- Biological elements;
- Hydro-morphological elements supporting the biological elements;
- Chemical and physical-chemical elements supporting the biological elements.

The hydrological regime forms part of the hydro-morphological quality elements and is recognised as a relevant variable that affects the ecological status of all categories of surface water bodies (i.e., rivers, lakes, transitional waters or coastal waters). A general description of ecological flows has therefore been provided within the context of WFD implementation as “a hydrological regime consistent with the achievement of the environmental objectives of the WFD in natural surface water bodies as mentioned in Article 4(1)”.

Under Article 4(1) of the WFD, the environmental objectives refer in general terms to:

- Non-deterioration of the existing status of rivers;
- Achievement of good ecological status (GES) in a natural surface water body;
- Compliance with standards and objectives for protected areas, as defined by the different international and national conventions and directives that apply in each instance, including those designated for the protection of habitats and species where the maintenance or improvement of the status of water is an important factor for their protection.

Currently, Georgia does not have holistic policy or clear legal framework to ensure proper management of water resources. Therefore, procedures to implement EF methodology should be reflected in the revised legal and regulatory framework.

# GENERAL CONSIDERATIONS

1.1. The assessment and protection of EFs in rivers and streams is an integral part of the Ministry of Environment and Natural Resources Protection of Georgia's (MENRP's) commitment **to protect the fundamental human right - to live in a healthy environment**.

1.2. Determinations of EFs are approved by MENRP.

1.3. The calculation of EFs using this methodology is a necessary component of the environmental impact assessment (EIA) and strategic environmental assessment (SEA) procedures related to the application process for a license or permit under the (draft) Code of Environmental Assessment.

1.4. The methodology is designed to be appropriate for use for perennial rivers and streams (i.e., surface waters flowing all year round) with the consideration that some flow remains in the river at any given time. With some adaptation, however, it can also be applied to temporary river and stream systems.

1.5. It is advisable to apply this methodology at the earliest possible stage of planning a water related development project that is likely to be subject to licensing or permitting. The methodology will principally pertain to the construction of dams for water storage and/or flood control, hydropower projects, major irrigation diversions, inter-basin water transfers, artificial reservoirs, offtakes for urban water supply, and any other hydraulic structures that modify or have the potential to modify the magnitudes and patterns of flow.

1.6. An environmental flow assessment (EFA) should also be made for any river or stream for which spatial or temporal changes in the sectoral use, future development, or ongoing management of water resources have the potential to change or have already detectably modified the hydrological regime or the ecological status of the waterbody.

1.7. The methodology can be applied by the water user, technical consultant, scientific-research organization, or other organization suitably qualified in this field, where the individual members of the multidisciplinary team undertaking the EFA and the results obtained can be deemed sufficiently impartial.

1.8. Certain procedural steps of the EF methodology are in their early stages of development and various constraints are known to exist in the availability of data, expertise and technical capacity. While designed to be sufficiently flexible and reliable for routine application in such contexts, the methodology is also amenable to further development.

# DEFINITION OF AN ENVIRONMENTAL FLOW

In the methodology, an EF is defined as: the quantity, timing, and quality of water flows and levels required to sustain freshwater ecosystems and the human livelihoods and well-being that depend on these ecosystems. The term 'environmental flow' has been adopted to reflect the inclusion of both ecological and social flow requirements.

EFs may vary depending on the level of ecological quality desired and agreed as an objective by the relevant stakeholders for a given river or stream. The methodology is designed so that a level of GES can be reached, in all probability, in accordance with the objectives of the (draft) Law of Georgia on WRM and of the EU WFD.

In select cases, still to be determined in relation to the (draft) Law of Georgia on WRM, where water bodies are formally designated as HMWB (and the aim for water body status is Good Ecological Potential) or qualify for an exemption, requirements in terms of the flow regime are to be derived considering technical feasibility and socio-economic impacts on the use that would be affected by the implementation of EFs.

# GUIDING PRINCIPLES

- In the absence of sufficient data and information about the flow requirements of aquatic species in the river or stream, the precautionary principle should apply and a higher level of flow should be protected.
- Where a greater degree of confidence is required in the EF recommendations and/or the higher the priority and importance of the river/stream reaches to be affected, a more comprehensive, and therefore also more resource intensive, EFA should be conducted. Confidence in and the level of resolution in the resultant EF requirement are typically proportional to the degree of effort invested in the assessment.
- There is no single minimum, constant flow year-round that will maintain ecosystem health. It is important to maintain and mimic as far as possible the natural patterns of flow variability of the river, within and between years.
- EFs cannot be defined purely on hydrological grounds. There must also be consideration of morphological, physio-chemical, social and ecological information. EF magnitudes (and other flow criteria) vary depending on the flow-related aspects of the biological life cycles and related habitat requirements of plant and animal assemblages and species inhabiting (or historically inhabiting) the river and its riparian corridor.
- Flow levels to meet ecological requirements are related to the natural flow regime (or other reference flow regime) of the river or stream under consideration, considering the magnitude, frequency, duration, timing, and rate of change of flows in the unregulated and unmodified flow regime.
- A holistic interdisciplinary method for assessing EF requirements is required. Expertise necessary for the assessment of EFs includes hydrology, hydraulics, morphology, ecology, water quality, and social sciences.
- Perennial rivers and streams should be maintained as flowing systems. Cease-to-flow conditions (as occur in temporary systems) should not occur under the recommended EF regime at any time, under usual climatic conditions. Extreme low flows as critical flows for survival should only be recommended under declared drought conditions or where curtailment of water use is required by all water users.
- Rivers and streams are physically and functionally connected ecosystems in time, as well as in space, longitudinally (e.g., river and estuary), laterally (e.g., river and floodplain) and vertically (surface water and groundwater). The recommended EF regime must ensure, as far as possible, system connectivity. Where the water resources infrastructure creates a physical or other barrier, additional measures must be put in place to help maintain connectivity (e.g., measures to ensure fish passage and sediment passage and to reduce changes in downstream thermal regime).
- While the focus is on the existing or potential impacts of flow regime alteration on the individual river or stream reaches selected for the EFA, consideration should also be given to the potential for any cumulative effects of hydrological alteration within the river/stream network.
- EFA addresses the flow-related impacts on the ecological status of the river or stream. Ecological status can be negatively impacted by different types of stressors, acting individually or in combination, not all of which are flow-related or mitigatable through flow management (e.g., land-use change, invasive species, and pollutants).

# STEPWISE PROCEDURE FOR ESTABLISHING AN EF REGIME

## OVERVIEW

A stepwise procedure of 14 main steps is required to establish the EF requirement for the river/stream system and sites of interest (Figure 1; see Section 4.2 for details).

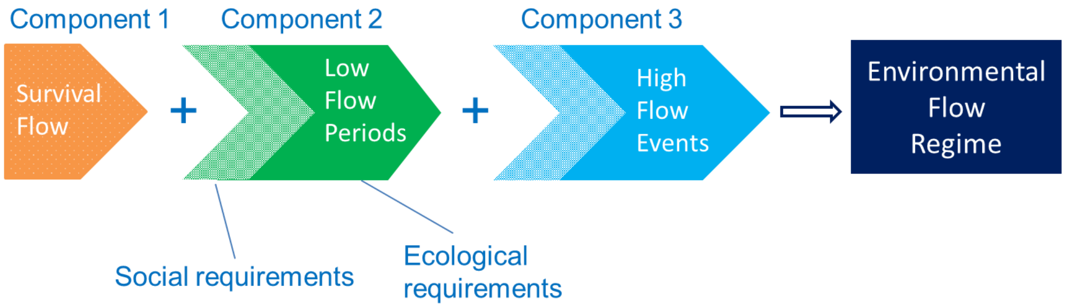
**Figure 1: The main procedural steps required to establish the EF requirements at a project site.**

| | |
|---|---|
| Step 1 | **Scoping and initiation of EFA** |
| Step 2 | **Appointment of EFA team** |
| Step 3 | **Delineation of study area and selection of EFA sites** |
| Step 4 | **Desktop and field hydrological, morphological, ecological and social analyses and surveys** |
| Step 5 | **Definition of reference conditions** |
| Step 6 | **Identification of river type(s)** |
| Step 7 | **Classification of present status of each site** |
| Step 8 | **Setting of EF objectives** |
| Step 9 | **Hydrological characterisation of each site** |
| Step 10 | **Determination of the survival flow** |
| Step 11 | **Determination of ecologically and socially relevant low flow periods** |
| Step 12 | **Determination of ecologically and socially relevant high flow events** |
| Step 13 | **Completion of the EF requirement schedule** |
| Step 14 | **Monitoring and reporting** |

The required EF regime is comprised of three main components (Figure 2):

1. **Survival flow** – The critical, extreme low flow recommended during a designated drought period;
2. **Low flows** – Low flows related to specific periods of ecological importance for indicator assemblages, species and life stages, ecological processes, and flows for important social and cultural features. The periods defined are generally one to six months each, and together result in a continuous low flow regime during the year;
3. **High flows** – High flow pulses and flood events of defined magnitudes extending over a specified number of days and intended for specific purposes, such as maintaining channel morphology or cuing ecological responses (e.g., fish spawning or migration). Additional criteria to describe a flow event may be used, including frequency or rate of the receding limb of the hydrograph.

**Figure 2: The three different flow components that in combination represent the recommended EF regime for a river or stream site.**




The EF is expressed as a schedule (table 1) specifying the discharges required for each of these components to meet a series of designated ecological and social requirements in normal years (and under drought conditions). The EF schedule should be sufficiently detailed to enable a recommended flow regime to be drawn up for implementation.

All components must be calculated for the EF requirements to be met, either through rules for the operation of the existing or proposed water resources infrastructure and/or standards limiting the withdrawal of water from a river or stream.

## OUTLINE OF THE MAIN METHODOLOGICAL STEPS

The following main steps and tasks are recommended for the EFA. Detailed guidance and illustrative examples for each of the steps in the methodology (see Figure 1) are provided in the supporting reference document (herein referred to as the Guide). It is recommended that the Guide be consulted at the earliest stage of initiating the EFA.

### Step 1: Scoping and initiation of the EFA

An initial scoping of the area of interest is conducted, led by the relevant agency or developer, to identify the issues of concern based on the proposed infrastructure project. The EF process is formally initiated and a coordinator, preferably with prior experience in EFA, is appointed to lead it. An initial plan for the assessment is drawn up and agreed. The process of identifying potential technical experts (local or international) for the EFA is started.

Any prescribed stakeholder process, for example as established for the EIA procedure, should also be initiated now. The scientific steps in the EFA should always be well aligned and integrated with the established, appropriate procedures for stakeholder engagement and consultation.

The methodology selected is required to be holistic, i.e., focused at whole ecosystem scale and able to address the flow-ecology-social relationships of multiple ecosystem components and processes. It is guided by the established tenets and concepts of holistic methodologies (see Guide for fundamentals). The level of detail required for the assessment is determined, taking into consideration factors such as:

- The urgency of the problem;
- The importance of the river or stream system;
- Development priorities;
- Resources available (viz., time, finances and available expertise);
- Data availability and quality;
- The level of confidence needed in the EF result.

Whether at a basic or more comprehensive level of resolution, all steps of the methodology should be applied.

The purpose and approach for establishing EFs should be well aligned with the current EIA/SEA and related procedures, as well as with any existing vision statement or River Basin Management Plan for the basin, where this information is available.

### Step 2: Appointment of the EFA

The EF coordinator must assemble and formally appoint a team of appropriately qualified professionals with scientific expertise in each of the disciplines required for conducting a holistic EFA.

The team must be multidisciplinary and its members should at least include experts in the areas of: hydrology; morphology and habitat hydraulics; river ecology; and social sciences. The team must be capable of producing an objective, scientifically defensible and rigorous result. Wherever possible, team members should possess local knowledge of the river system or at least regional experience in their own discipline. Prior experience in EFA is an advantage.

### Step 3: Delineation of the study area and selection of the EF sites

With the input of the multidisciplinary team, delineate the boundaries of the study area (basin(s), river system and potential river/stream reaches) and select the number and locations of EF study sites. Potential locations of sites are identified based on:

- Present and future river use and project impacts on hydrology, ecology and social use;
- Complexity of the system;
- Requirements for implementation, including management control points.

As a guide, approximately two to four sites should be assessed for a single project.

Site(s) should be located as to be representative of the reach (es) of concern. At least one site should be located downstream of the project, not immediately below any hydraulic infrastructure but at a sufficient distance to reflect any existing or potential flow-related impacts. Any additional critical sites should be included (e.g., a reach with high conservation value, a critical reach for access to coastal waters by long distance migratory species or a tributary low flow refuge). One or more sites should be in the designated reference reach (es).

### Step 4: Desktop and field hydrological, morphological, ecological and social analyses and surveys for each site

Collate the existing data, information and knowledge for the river basin and each of the EF study sites. All known sources of data, information and knowledge pertinent to the site(s) should be compiled and summarized, including:

- Published scientific literature;
- Published and unpublished technical reports (e.g., EIA and SEA reports, hydropower pre-feasibility studies, project consultancy reports, and other development reports);
- Other products of completed and ongoing projects;
- Existing local, regional and global data (e.g., remotely sensed imagery, regional databases, and global data sets).

Attention should be given to any empirical studies that qualitatively or quantitatively address flow-ecology relationships.

It is recommended that a desktop situation assessment of present conditions within the study area be conducted first, based on an analysis of existing information. This should include a rapid screening of pressures/stressors to identify the most relevant sources and locations of flow-related and, also, non-flow related impacts, including those which, while external to the project, may exert cumulative effects on the system.

Field surveys should be made for each of the specialist disciplines represented in the EF team. Team field visit(s) by experts should preferably be made in both the dry and wet seasons, to reflect seasonal difference in flow requirements. At a minimum, at least one field visit should be made by the team together, ideally during the low flow season. The information collected is used in all subsequent steps of the procedure (steps 5-14). It is essential for the calculation of the discharges representing the survival flow, and the low and high flows, as well as for the supporting motivations required.

Standardized field survey protocols should be used, where available (see Guide). Attention should be paid to the standard methods and protocols already in use by the National Environmental Agency (NEA) for the assessment of the ecological status of rivers and streams, including by river/stream type, as these are readily usable for EFA. Additional sources of information should be considered within the ecological and social surveys, including the indigenous knowledge held by local people.

The following studies should be conducted at or for each site, as appropriate, by the relevant expert:

- Hydrological survey and analyses, including modelling studies where time series of observed flow data are absent or incomplete;
- Morphological survey and analyses, including a standardized morphological assessment, a cross-sectional hydraulic survey of the reach, and habitat simulation modelling of the physical habitat requirements of indicator species and/or assemblages at different flow levels;
- Ecological surveys and supporting data analyses for fish, macroinvertebrates, and instream and riparian vegetation, as well as any other important ecological components or processes;
- Water quality survey, including in situ sampling and the laboratory analyses of at least the major chemical constituents;
- Social survey and analysis.

Short synthesis reports should be produced by the individual experts and compiled by the coordinator, to produce a report of the EFA to help guide and inform the subsequent steps.

## Step 5: Definition of reference conditions

Establish suitable reference conditions for the sites.

Typically, the sites to be used as reference sites should be as close to natural as possible (i.e., natural and intact, or near-natural/minimally altered) to assist in understanding the natural relationships that can be expected to occur between river flow regime and ecology. However, as such unaltered sites rarely exist, the ‘reference’ condition used can be set as the ‘least degraded’ condition or as the present-day condition.

## Step 6: Identification of river type(s)

At least a basic analysis should be made of the type(s) of rivers and streams represented by the EF sites and their corresponding reaches.

This allows for more effective comparisons to be made among sites, including in relation to reference conditions, where there are broad similarities or differences in site characteristics. It is also important because some field procedures are tailored for different types of systems, as are the associated metrics used to assess site ecological status (e.g., as is the case with some NEA protocols; see Guide).

Features that can be used in various combinations to group rivers/streams into types include, among others, basin physiographic attributes, such as catchment size, geology, altitude, as well as river size, overall hydrological character, and aquatic ecoregion.

## Step 7: Classification of present status of each site

A basic classification should be made of the present ecological status of each site, based on the understanding of hydro-morphological, biological and physicochemical conditions gained from any routine or baseline monitoring studies, as well as the from desktop and field surveys and analyses conducted in step 4. Based on the WFD framework for classification, a site can be classed as being in high, good, moderate, poor or bad status.

The results of the classification provide an integrated signal of how altered from natural each site is in terms of its present conditions, and of the extent to which flow protection or restoration is or will be required to meet the general objective of GES.

Once a classification system for the ecological status of surface waters of Georgia is fully developed, it should supersede the current procedure.

## Step 8: Establish EF objectives

EF objectives are clear narrative statements of what outcomes should be achieved in providing EFs. Environmental objectives are developed for those ecological components that have a clear dependency on some aspect of the flow regime, including communities and individual species, habitats and ecological (physical and biological) processes. Objectives should also be developed for any social factors for which there are relationships with the flow regime.

Each objective should be able to be linked directly to specific and measurable scientific endpoints for monitoring purposes, and appropriate indicators and metrics (see step 14: Monitoring and reporting; see Guide). There should be a clear link between the EF objectives and the objective of achieving GES as per the WFD.

## Step 9: Hydrological characterization of each site for the EF calculation

The natural flow regime of each site must be characterized by the hydrologist. The following main tasks are required for this purpose, and rely on hydrological best practice methods and tools (see Guide):

- Acquire the long-term record of daily average discharges from the national hydrological monitoring program (or other sources, e.g., flow records maintained by the operators of hydraulic infrastructure) for flow gauging stations close to the sites;
- Select the reference period for the historical flow time series (as long a record as possible, to cover dry and wet years) for the site(s);
- Check the data record for stationarity, consistency and homogeneity using standard data processing techniques (e.g., Spearman's rank-correlation, double-mass analysis);
- Interpolate and/or extrapolate records from nearby stations to generate time series of observed or estimated daily average discharge using standard regression or equivalent techniques;
- Reconstruct the natural flow regime for the reference period, adding back any flow changes due to anthropogenic effects (and noting any potential changes due to climate change);
- Analyze the time series of daily average discharges to calculate a set of ecologically relevant flow statistics (annual, monthly and flow event-based indices). The use of the Indicators of Hydrological Alteration (IHA) software, among other potential tools, is recommended for this task (see Guide).

Similarly, the type and degree of flow alteration from the reference condition at each site should be ascertained and characterized based on the present-day or projected future flow time series with the project in place, using the same standard hydrological methods and tools for the analyses.

## Step 10: Determination of the survival flow

Calculate the survival flow (Figure 2) as a minimal critical discharge (flow level) that must be maintained in the river or stream during only a declared drought, to safeguard its perennial character and maintain basic ecological connectivity and survival habitat for the biota. In its present form, the step is a hydrological one. No site-level ecological data or information on cultural services and other social uses of the river/stream at the site are needed.

The recommended flow should be based on a standard hydrological analysis of the daily flow time series and can be presented as at least an annual, but more preferably a seasonal (wet and dry season) or monthly discharge for all months of the year for which drought conditions prevail.

As a default, the procedure for calculating the survival discharge should follow that recommended in the Austrian EF ordinance. Under this ordinance, the minimal critical discharge must:

a) Exceed the value for the natural lowest daily minimum flow over the historical period of record;
b) Account for at least one third of the natural mean annual minimum flow in water bodies for which the value for the natural lowest daily minimum flow is below one third of the natural mean annual minimum flow;
c) Account for at least half of the natural mean annual minimum flow in water bodies for which the mean water discharge is below 1 cubic meter per second and the value for the natural lowest daily minimum flow is below half of the natural mean annual low flow.

## Step 11: Determination of ecologically and socially relevant low flow periods

The tasks in this step consist of an assessment of the ecological (i.e., biological, morphological and physicochemical) and social requirements for the important low flow periods of the year, followed by the description of the specific flow conditions required during each of those periods to support those requirements (see Guide for further details).

Ecological requirements for low flows:

- Check the historical records of occurrence of aquatic and riparian species in the river basin. Identify the expected species at the reference and other site(s). One source of historical information is The National Atlas of Georgia (Tbilisi 2012), but bibliographic research to identify additional historical records is encouraged;
- Conduct an ecological field survey (if no data are available) of the site(s) and nearby areas. Identify the different species/taxa of macroinvertebrates, fish, macrophytes and floodplain plants and algae present (or potential) using standard ecological surveying methods. Ideally, this survey should be done during dry-season low water conditions. A second survey at higher flows (wet season) is also recommended;
- Select indicator species/guilds/assemblages or other ecologically meaningful groupings of organisms for the relevant ecosystem components (fish, macroinvertebrates, vegetation) either from field studies, or, if the species are not encountered, from historical data;
- Identify the habitat requirements for different times of the year and at different life stages (biological periods) for the set of indicator species/guilds/other groups. This identification may be accomplished through a combination of literature review, expert knowledge and field surveys;
- For priority instream biota (e.g., fish, benthic macroinvertebrates, and potentially also aquatic macrophytes), their physical habitat requirements should be described in terms of hydraulic attributes (substratum composition, water depth, current velocity, flow types and cover, etc.). A cross-section based hydraulic survey of the reach may need to be conducted at different discharges to describe the available habitat and its relationships with flow (see Guide). In the case of morphologically highly dynamic rivers, such as braided alluvial systems, cross-section profiles are liable to change often over time, necessitating repeat surveys. Using the field survey data, habitat simulation analyses for the target biota should then be performed, using appropriate methods (e.g., the System for Environmental Flow Analysis, SEFA) to derive suitable flows to support species life cycle needs (see Guide for details);
- Select the largest magnitude flow requirement of indicators during each biologically relevant low flow period, such that the selected flow level meets the requirements of all indicator species during that period;
- Collect and acquire data on the seasonal oxygen conditions, temperature regime, and other relevant water quality parameters of each study site/reach. If such data are not available, conduct a field survey(s) using standard protocols (e.g., NEA protocols);
- If applicable, define any upper (maximum) discharge limits, for example, to avoid unnaturally high velocities during sensitive ecological stages (e.g., the fish fry life stage). The maximum flow is a flow level not to be exceeded during a given biological period and is set to avoid artificially high flows related to dam releases (e.g., hydropower generation during peak demand periods or within-daily flow fluctuations due to hydropeaking, or seasonal flow reversals with dry season irrigation).

Social use requirements at low flows:

- Identify and inventory instream and riparian cultural services and other uses by people during different months in the vicinity of the site (e.g., recreational fishing and use of river beaches). This may be accomplished through consultations with local communities, using standard social methods and tools (e.g., participatory rural appraisal), and literature review;
- Assess the flow levels required to meet the identified uses in different low flow periods. This may be accomplished through a combination of hydrological and hydraulic habitat analyses.

Combine and compare the ecological and social requirements for low flow periods and select the largest magnitude of the different values for each period. This schedule of flow levels during different periods (biological periods or months) constitutes the low flow component of the EF requirement (Figure 2).

## Step 12: Determination of ecologically and socially relevant high flow events

In this step, the major river processes typically associated with different high flows (i.e., high flow pulses, and intra-annual and inter-annual small and large floods; Figure 2), including sediment transport and the maintenance of river channel form, should be considered.

Specific high flow requirements for different ecosystem components (e.g., cues for fish migration and spawning; and floods that promote recruitment of floodplain tree species or seed dispersal) and for various social uses (such as, maintenance of culturally important or aesthetically valued features, such as waterfalls; economic uses for tourism, e.g., river rafting; or the formation of important morphological features, e.g., river beaches) should also be considered:

- Assess the magnitude, duration, timing, frequency and other relevant criteria (rate of change, hydrograph shape, etc.) of individual high flow events required to meet the needs for sediment transport, physical habitat creation and maintenance of channel form, and for other morphological features. This may be accomplished through a combination of field morphological surveys, and hydraulic and geomorphological modeling;
- Identify the specific ecological and social requirements for high flows (e.g., migration or spawning cues for long-distance migratory fish species; or the high flow magnitudes for rafting). This may be accomplished by means of hydraulic habitat analysis, in a similar manner to that of the previous step 11;
- Prescribed high flow events should be characterized based on an analysis of high flows observed in the historical discharge record of the site (e.g., flood frequency analysis). For instance, recommended high flows may be lower than historical magnitudes and of similar return periods, but should not exceed them;
- Consider both within-year and between-year variability in high flow events. Certain flood events, typically small and bank full floods, may be required at least once a year every year, while others, such as large channel forming events, may only occur naturally once in every few years and therefore are not required every year.

The various ecological and social requirements for high flow events should be combined into as few individual events as possible, where the criteria describing each event are sufficiently similar in character. This set of discrete events constitutes the high flow component of the EF requirement (Figure 2).

## Step 13: Completion of the EF requirement schedule

Transfer all the individual flow recommendations for survival flows, low flow periods and high flow events to the Environmental Flow Requirement Schedule. The schedule must be reviewed for completeness.

Table 1 provides a hypothetical example for an EF site for a coastal river type. The specific recommendations, and accompanying EF hydrograph, might differ for other sites within the same river system and for other types of rivers across Georgia (see Guide).

The finalized schedule constitutes the enforceable EF regime (e.g., as illustrated in Figure 3, for the same hypothetical river type) to be applied in the operation of hydraulic infrastructure (e.g., operational rules for flow releases from a dam) or the withdrawal of water from water courses (e.g., as limits on abstractions).

**Table 1: Illustrative example of a hypothetical Environmental Flow Requirement Schedule for a site, for a coastal river type.**

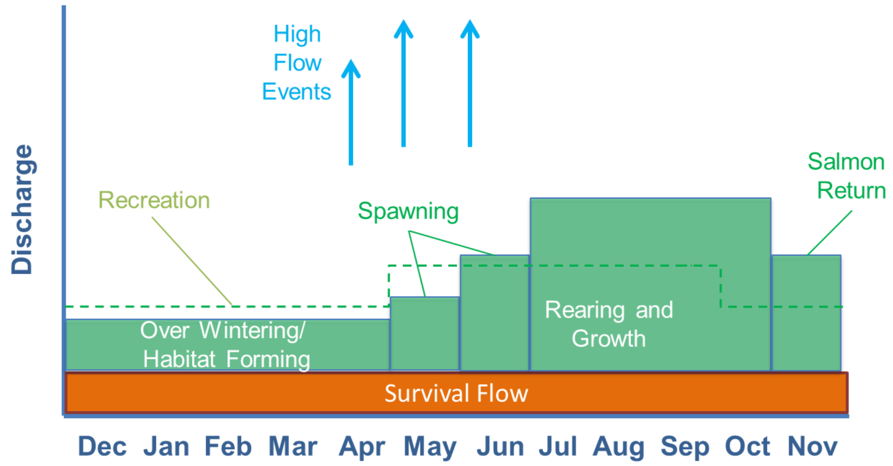
| **Survival Flow** | | | | |
|---|---|---|---|---|
| **Period** | **Effective Dates** | **Discharge ($m^3 s^{-1}$)** | **Percentile ($Q_t$) from Annual FDC**** | |
| Annual | Jan – Dec | Value | Value | |
| **Low Flow Periods** | | | | |
| **Period Criterion/Type*** | **Effective Dates** | **Discharge ($m^3 s^{-1}$)** | **Percentile ($Q_t$) from Annual FDC**** | **Other flow criteria** |
| Over Wintering | Dec - Feb | Value | Value | |
| Habitat Forming | March – April | Value | Value | |
| Spawning 1 | May | Value | Value | |
| Spawning 2 | June | Value | Value | |
| Rearing and Growth | July – October | Value | Value | |
| Salmon Return | November | Value | Value | |
| Social Use for Recreation | December – May | Value | Value | Upper limit to flow magnitude |
| **High Flow Events** | | | | |
| **Motivation** | **Timing** | **Duration** | **Magnitude** | **Other flow criteria***** |
| Channel Sediment Flushing and Maintenance | early April | 3 days | Value | |
| Spawning Cue 1 | early May | 3 days | Value | |
| Spawning Cue 2 | early June | 4 days | Value | Slow hydrograph recession rate |

** The periods shown in this example relate to biological periods, but periods based on flows to preserve social instream uses and cultural features may also be listed here (if information and data are available).*

*** Annual FDC – Annual Flow Duration Curve derived from daily discharge data.*

**** Other flow criteria may include: event frequency, rate of change in flow (e.g., ramping up or down in the case of hydropeaking), hydrograph shape, upper or lower discharge limits).*

**Figure 3: Illustrative representation of the different components of the EF regime to meet specific ecological and social requirements. This example is for a hypothetical coastal river.**



## Step 14: Monitoring and reporting

Monitoring and reporting are critical to ensure practical implementation of the recommended EF regime (the schedule), from monitoring of compliance with the recommended flows and progress towards the achievement of GES, through to adaptive management to refine or update the flow recommendations, fill in gaps in understanding, and address any critical areas of uncertainty.

Standard protocols for the monitoring of biological, hydro-morphological (including hydrological) and physicochemical conditions should be used, where available (e.g., NEA monitoring procedures, see Guide). Monitoring should be tiered, where possible, and include both simple, rapid measures of system response to flow regime, as well as more detailed technical indicators.

Attention should be given to monitoring hydrological and ecological conditions at the same time and within the same reach, to ensure that the flow-ecology relationships obtained accurately reflect site conditions.

Indicators should cover the diversity of ecosystem components and indicator species, and encompass indicators that show both rapid, short-term (e.g., physical habitat hydraulics) and slow, long-term (e.g., changes in channel morphology and composition of riparian vegetation) responses to flow regime. Ideally, monitoring should take place seasonally, to ensure both low flow and high flow periods of the year are addressed. Harmonization across different monitoring methods (e.g., time periods, level of resolution, and locations) is desirable.

Reporting of monitoring results should be clearly laid out and readily understandable, standardized and regular. It should coincide as closely as possible with any requirements for licenses or permits for water infrastructure or abstractions, reviews of management performance, or changes to major plans or procedures (including River Basin Management Plans).

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