MEXICAN STANDARD NMX-AA-159-SCFI-2012

WORKBOOK

MEXICAN STANDARD NMX-AA-159-SCFI-2012

THAT ESTABLISHES THE PROCEDURE TO DETERMINE THE ENVIRONMENTAL FLOW OF HYDROLOGICAL BASINS

WORKBOOK

Con el apoyo de la Alianza

CONAGUA
Comisión Nacional del Agua

WWF

FUNDACIÓN
GONZALO RÍO ARRONTE, I.A.P.

BID
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The purpose of this workbook is to implement the Standard through the National Water Reserves Program. If you have any comments or suggestions please direct them to the following email:

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Foreword

On September 20, 2012, The Mexican Standard NMX-AA-159-SCFI-2012, which establishes the procedure to determine the environmental flow of hydrological basins, was published in the Official Journal of the Federation. This standard is an essential tool for the recovery and conservation of ecological functionality of the hydrologic cycle, and is also an instrument to systematically control the alteration of this cycle and its effects on biodiversity, in the face of increased water usage.

The journey which led to this standard began in 2007, when the National Water Commission (CONAGUA) invited us to form part of the task force for its development. At that time, the experiences of environmental flow determination in the country were limited to studies conducted by the Mexican Institute of Water Technology in 1996, and the early work of the partnership created between the Gonzalo Rio Arronte Foundation, I.A.P. and the World Wildlife Fund (WWF) proposing new models of water management in Mexico.

These pioneering works focused on both: determining ecological flows from a holistic method called the Building Block Methodology (BBM) classified as holistic and recognized for its reliability; and in applying it, in every detail, to the Conchos River in Chihuahua, in order to subsequently replicate it in two additional basins: the basin formed by the Copalita-Zimatán-Huatulco rivers in Oaxaca, and that of the San Pedro Mezquital River in the states of Durango, Zacatecas and Nayarit.

The synthesis of these experiences, which involved more than 100 experts, generated enough knowledge to nurture and illuminate the discussions of the working group of the standard. In 2012 the final version was developped and published.

This standard sets out the principles and procedures for determination of an ecological flow regime. This concept is recognized by the National Water Law as "the minimum required flow or volume in bodies of water, including different types of streams or reservoirs, or the minimum flow of natural discharge of an aquifer that must be maintained to protect the environmental conditions and ecological balance of the system.".

One of the most important aspects of the standard is the establishment of environmental objectives based on a balance between ecological importance (determined from instruments developed by CONABIO, CONANP and INE) and the pressure from water use in each of the 732 hydrological basins in the country. Another aspect is the hierarchical incorporation of different methodologies depending on the complexity of the basin to be analyzed.

This standard is undoubtedly one of the most advanced in the world, not because of its complexity, but because it is founded on scientific principles and proposes environmental flows as a water management tool, which combines water use with the conservation of ecosystems and their services, at different levels of protection or use.

The standard stems from the water management experience, and consideration of the environment as the provider of this resource, in a collaborative effort led by CONAGUA, and the WWF-Gonzalo Río Arronte Foundation Alliance, and with the active participation of the following institutions and organizations: IMTA, Institute of Biology and Institute of Engineering of the UNAM, The National Institute of Ecology (INE), the Federal Commission of Electricity (CFE), SEMARNAT, CONANP, CONABIO and The Nature Conservancy.

WWF-México
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Preface

The following companies and institutions participated in the development of this Mexican Standard:

- FEDERAL COMMISSION OF ELECTRICITY (CFE).
  South Pacific Preliminary Projects Center.

- NATIONAL WATER COMMISSION (CONAGUA).
  General Sub Directorate of Water, Sewage and Sanitation.
  General Technical Sub Directorate.
  General Sub Directorate of Programming.

- NATIONAL COMMISSION OF NATURAL PROTECTED AREAS (CONANP).
  Directorate of Regional Operation Strengthening.

- NATIONAL COMMISSION FOR KNOWLEDGE AND USE OF BIODIVERSITY (CONABIO).
  Directorate of Analysis and Priorities.

- MEXICAN INSTITUTE FOR WATER TECHNOLOGY (IMTA).
  Coordination of Treatment and Water Quality.
  Sub Coordination of Hydrobiology and Environmental Assessment.

- NATIONAL INSTITUTE OF ECOLOGY (INE).
  Directorate of Integrated Hydrological basin Management.

- SECRETARY OF ENVIRONMENT AND NATURAL RESOURCES (SEMARNAT).
  General Directorate of Primary Industry and Renewable Natural Resources.

- THE NATURE CONSERVANCY - LATIN AMERICA.
  Directorate of Environmental Policy in Latin America.

- NATIONAL AUTONOMOUS UNIVERSITY OF MEXICO (UNAM).
  Institute of Biology.
  Department of Zoology.
  Institute of Engineering.
  Coordination of Environmental Engineering.

- WORLD WILDLIFE FUND, INC. MEXICO PROGRAM OFFICE (WWF-MEXICO).
  Water program.

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That establishes the procedure to determine the environmental flow of hydrological basins.

0. Introduction

In order to maintain the balance of the natural elements of the hydrological cycle and to allow protection of riparian ecosystems, and terrestrial and coastal aquatic ecosystems, it is necessary to ensure an ecological flow regime in streams and rivers.

A nationwide problem exists concerning the decrease of water in channels that results from competition between uses and the lack of regulation in accordance with the availability of this resource, for example, water demand from sites upstream from hydrological basins, does not contemplate the conservation of a runoff towards the lower parts, and, as in the case of groundwater, does not consider aquifer discharge into bodies of surface water.

As there is no specific regulation regarding ecological flow, concessions, allowances, and discharge permits, the need to establish a flow regime was until now not fully considered, but it is of great importance to the preservation of ecosystems: rivers, lakes, lagoons and estuaries.

The definition of ecological flow is the quality, quantity and flow regime or varying water levels required to maintain the components, functions and processes of epicontinental aquatic ecosystems. For purposes of this standard, flow and environmental flow are considered synonymous with ecological flow. This implies that in addition to providing water for domestic use, urban public use, and livestock and agriculture, it is possible to maintain flows both from runoff, as well as discharges from aquifers for the conservation of lotic (perennial, intermittent and ephemeral rivers), lentic (lakes, ponds, and wetlands), and riparian ecosystems with input from aquifers into the ecosystem, which serve to conserve biodiversity and environmental services.

To determine the ecological flow regime, many methodologies have been developed internationally. These are classified according to the manner in which they approach or address the problem. The present challenge is how to choose the most appropriate method, and this depends on the compliance of with the principles or foundations which are currently valid.

The main scientific principles for determining ecological flows are: the paradigm of the natural hydrological regime and the gradient of the biological condition. This implies that any methodology will be valid as long as it focuses on understanding the ecological significance of each component of the natural regime, and if it generates proposals for its conservation or restoration in whole or in part, from the functional point of view. Likewise, any methodology will be valid if it recognizes that an aquatic ecosystem changes its services in response to increased levels of stress. In this manner and from the conceptual viewpoint, any procedure for ecological flow determination will start by recognizing the natural conditions of the hydrological regime, its altered state, and the possibilities of conservation or recovery of the components of the hydrological regime to achieve or maintain a desired ecological state or environmental objective.

The environmental flow regime is a water management tool based on the ecological principle of the natural regime and the biological condition gradient, and seeks to establish a flow regime that is able to sustain water use, storage needs, and ecosystem health throughout the year.

Hydrological methodologies are the simplest, and in these, the ecological flow is determined through the study of a series of historical flows. An example of hydrological methodologies, in which ecological flow is defined as a percentage of historical mean flow, is the **Tennant or Montana** method. Such methodologies have the advantage of being simple in terms of implementation, which coupled with a relatively low amount of information required, allow results to be obtained in the short term. Besides these, there are others where it is necessary to use more detailed methods, such as **Physical Habitat Simulation** (PHABSIM) which consists of a more detailed analysis of the quantity and suitability of the physical habitat available to biota under different flow conditions, linking hydrological, hydraulic and biological information, which requires a considerably greater amount of information, time and in general, more resources. Finally, holistic methodologies, such as the **Building Block Methodology** (BBM) and the **Downstream Response to Imposed Flow Transformation** (DRIFT), used on sites with a high variability in the flow regime, where large dams have been built thus transforming basin characteristics, require historical records of flow, hydraulic variables and models that relate flow to requirements of certain components of the ecosystem, as well as economic and social information (Appendices C, D, E and F).

It is observed that the determination of ecological flow should be applied to streams of each hydrological basin and to bodies of water, since they are necessary in order to limit the extraction of national water, establish closed areas or declare water reserves, in such a manner that they may be incorporated into decisions made to grant or deny concessions and water allocations, as well as granting discharge permits within the guidelines set by the Water Authority.

Therefore, this standard sets out the corresponding methodologies for determining ecological flow as a measure to regulate exploitation, use and conservation of water, to protect the related ecosystems, in order to promote sustainable development in hydrological basins.

In cases where the stream or body of water is situated in banned or unavailable hydrological basins, it will be possible to ascertain the ecological flow. However, it cannot be granted administratively. This determination allows the identification of volumes allocated or assigned to users, which have an indirect environmental function as they flow through the channel.

1. Objective

This Mexican Standard establishes the procedure and technical specifications to determine the ecological flow regime in national streams or bodies of water in a hydrological basin.

2. Fields of application

This Mexican Standard applies to all those who conduct studies in order to request allocations, build infrastructure, and make transfers between basins, similar to an Environmental Impact Assessment (EIA).

It also applies to all streams or bodies of water, whose agreements for water availability published in the Official Journal of the Federation (DOF), do not take flow into consideration for the conservation of aquatic ecosystems.

3. References

For the correct application of this Mexican Standard, the following official Mexican Standard(s) in force, or those that replace it (them), should be consulted.

NOM-011-CNA-2000 Conservación del recurso agua - Que establece las especificaciones y el método para determinar la disponibilidad media anual de las aguas nacionales, **(Conservation of water resources – Establishes the specifications and method for determination of the mean annual availability of national waters.)** Published in the Official Journal of the Federation on 17 April 2002.

NOM-059-SEMARNAT-2010 Protección ambiental - Especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-Lista de especies en riesgo, **(Environmental Protection – Native Species of Wildlife Flora and Fauna in Mexico- Risk categories and specifications for inclusion, exclusion or change, List of Species at Risk.)** Published in the Official Journal of the Federation on 30 December 2010.

4. Definitions

For purposes of this Mexican Standard, the terms and contents of the current Mexican Official Standards NOM-011-CNA-2000 and NOM-059-SEMARNAT-2010 apply, and the following definitions are established.

4.1. **Tributary:** Or stream which flows into another river, which it joins in a place called a confluence.

4.2. **Eco-hydrological alteration:** Induced modification of the quality, quantity and temporality of hydrological regimes, principally caused by hydraulic, road, and urban infrastructure, which alter the provision of environmental services.

4.3. **Flood:** Sudden increase in volume and velocity of flow in a river due to runoff generated by cyclic or extraordinary rain.

4.4. **Biotic:** Pertaining to living organisms. Component of the ecosystem.

4.5. **Volumetric Flow:** Or volume that passes per unit of time. For purposes of this standard, flow and discharge are considered synonymous.

4.6. **Ecological flow:** The quality, quantity and flow regime or varying water levels required to maintain the components, functions and processes of epicontinental aquatic ecosystems. For purposes of this standard, flow and environmental flow are considered synonymous with ecological flow.

4.7. **Mean annual flow or runoff:** The average flow of 365 days per year, calculated from number (n) of daily records for several years.

4.8. **Ordinary seasonal flow:** Is the flow that occurs in ordinary conditions of drought and rainfall, in a particular section of the body of water, according, to its natural range and variability, and in a given time.

4.9. **Biological corridors:** They are bridges between natural reserves that allow movement of species, particularly those with large space requirements. They help preserve the structure of ecosystems, and provide a number of environmental services.

4.10. **Riparian ecosystems:** Located on the banks of rivers, streams and bodies of water, they are biological corridors between areas of headwaters of hydrological basins and the ocean. They provide various environmental services, such as filtering sediment and pollutants that are washed from the upper parts of the basin by rivers. They mitigate the impact of floods, are productive areas for nutrient and moisture accumulation, and they increase connectivity and integrity of the basin since they facilitate the dispersion and mobility of species.

4.11. **Epicontinental aquatic ecosystems:** Ecosystems which have as a biotope any continental body of water, such as: rivers, lakes, marshes, wetlands, lagoons, estuaries.

4.12. **Ecological integrity:** Refers to the intensity of degradation of a certain area or ecosystem produced by human and other activities, and that has as a consequence, the loss or transformation of the area's or ecosystem's structural and functional characteristics.

4.13. **Intra-annual:** Refers to changes to annual hydrographs that determine dry, average and wet (or rainy) years.

4.14. **Environmental objective:** Desired ecological status to be reached within the hydrological basin to maintain the integrity of existing ecosystems, or when it is believed that they are degraded, to contribute to their recovery or rehabilitation.

4.15. **Riparian zone:** A riparian zone or shoreline habitat is the interface between land and a river or stream. It is the habitat of wildlife communities along river margins and banks. Generally the riparian zone includes the federal zone.

4.16. **Regime:** Intra and inter annual variability that exhibits a trend of natural evolution of a river or body of water. There are no obvious anthropogenic disturbances.

4.17. **Exchange Rates:** The difference between two successive values in a hydrological series, per unit of time, for conditions of both ascent and descent of flow.

5. Specifications

5.1. General.

5.1.1. The specifications in this Mexican Standard should be applied in studies to determine the regime of ecological flow in national streams or bodies of water at the hydrological basin level. The methodologies described in this standard are considered the minimum technical requirement and do not exclude the application of complementary methodologies or more accurate alternatives when available information or resources permit, in such a case the National Water Commission will determine which results prevail, taking into consideration the level of detail of the studies and considering the interests of the users, to determine the final results.

5.1.2. Determination of the ecological flow regime in streams or bodies of water in hydrological basins can be subdivided as a function of regional issues facing the use of this resource, the importance of its tributaries and associated aquifers, the location of different users, and hydro-climatological information available.

5.2. Criteria and Methodologies for calculating the regime of ecological flow.

5.2.1. Determination of environmental objectives: these are established based on the ecological importance and pressure from water use.

5.2.1.1. The category which prevails will be that which is associated with the most relevant criteria

TABLE 1. Ecological Importance.

	Biotic aspects	Aspects of Ecological Integrity	Eco-hydrological Alteration
Very high	One or more species endemic to the region or that also have international relevance, that are found in some state of protection under NOM- 059-SEMARNAT-2010 and / or on other similar international lists.	Habitat unique for its diversity and function, which maintains its natural structure and the ecological integrity associated with ecosystem services provided, which are intact. The catchment area is preserved.	None or minimal. The natural regime is preserved.
High	At least one species of regional or national relevance under some protection status in NOM-059-SEMARNAT-2010 or similar international listings.	Habitat unique for its diversity and function, the natural structure predominates, it essentially retains its ecological integrity, and consequently, the ecosystem services it contributes. The catchment area is preserved.	Minimal presence of anthropogenic infrastructure (roads, farms, discharge of domestic waste waters). Moderate alterations to natural regime.
Medium	Presence of populations from different species, of regional relevance for their contribution to ecosystem services or socioeconomic development.	The catchment area and habitat are moderately impaired. Functioning, structure and basic services are somewhat conserved despite physical changes that present.	Evident presence of anthropogenic infrastructure. Apparent and significant alterations but certain components of the hydrological regime are maintained.
Low	Zero or very low presence of native species with the presence of exotic species.	Catchment area subject to severe water stress and land use change. Channels invaded, obstructed, abandoned, modified, or destroyed by extraction activities, which changes, in extreme cases, are irreversible. Ecological integrity is completely lost and sometimes only basic environmental services are preserved.	High presence of anthropogenic infrastructure. Regime completely altered.

5.2.1.2. Pressure from water use: it is determined as the percentage ratio of allocated plus under concession volumes divided by the mean annual availability per basin or aquifer, according to the information published by the National Water Commission. The level of pressure from use is set according to the values of TABLE 2.

TABLE 2. Pressure from Use

Pressure from Use	Very High	High	Medium	Low
	≥ 80 %	≥ 40 %	≥ 11 %	≤ 10

5.2.1.3. Under the rules of decision shown in TABLE 3, the environmental objective must be assigned to the hydrological basin under study.

TABLE 3. Matrix of Environmental Objectives.

Ecological Imortance					
	Very High	A	A	B	C
	High	A	B	C	D
	Medium	B	C	C	D
	Low	B	C	D	D
		Low	Medium	High	Very High
		Pressure from Use			

The list of environmental objectives for each hydrological basin in Mexico is shown in NORMATIVE APPENDIX A.

Ecological flow should be determined on the basis of the environmental objective identified through the objectives established in Table 3, whether in surface streams, in receiving bodies of various types, or as part of the natural discharge of an aquifer, which must be preserved in order to protect the environmental conditions and ecological balance of the system.

5.2.2. To determine the ecological flow regime, any methodology is valid if:

i) It allows understanding of the ecological significance of each component of the natural hydrological regime, and generates proposals, from the functional viewpoint, for its complete or partial conservation or restoration.
ii) Its proposals consider the natural interval of hydrologic variability, both under ordinary conditions and under a regime of disturbance; and
iii) It recognizes that an aquatic ecosystem changes its attributes in response to increased levels of stress, and therefore admits adjustment of proposals of ecological flows, to environmental objectives, or to conservation of the river.

The result of the ecological flow should be congruent with the conservation objectives, starting with those that were identified as priority conservation areas.

5.2.2.1. Hydrological Methodologies: Provide guidelines to establish a regime as a percentage of mean annual runoff, and which, it is assumed, will maintain biological attributes in certain levels of conservation.

For a basic level analysis, adequate for water planning, or for zones where there is low water use conflict, internationally recognized hydrological methodologies will be applied for determining mean annual runoff based on the analysis of the natural regime (RN) and the altered regime (RNA) of the representative historical hydrological series. The methodology for determining whether a hydrological regime is in a natural or altered state is defined in Normative Appendix B. The application of hydrological methodologies should determine the mean annual runoff that corresponds to the reference value for the previously defined environmental target.

In hydrological basins where the regime resulting from ecological flow represents a conflict due to infrastructure operations, where under present conditions a determined ecological flow can be reconciled with regard to its annual average, but not regarding its regime; or per assigned volumes, where the reference value for the assigned environmental objective cannot be met, the hydrological methodology should analyze:

i. Ordinary seasonal flow regime for humid, average, dry and very dry hydrological conditions;

ii. Flood regime, considering at least three categories of floods (intra-annual, low magnitude inter-annual, and moderate magnitude inter-annual) with corresponding attributes of magnitude, duration, frequency, time of occurrence and rate of exchange.

By comparative analysis of hydrologic series in natural conditions with hydrological series modified by infrastructure present in the study unit with conflicts of operation. This level of analysis should determine the final volume of ecological flow, taking into consideration the reference value to achieve the previously defined environmental objective.

In NORMATIVE APPENDICES C and D, hydrological methodologies are established based on the use of reference values, as well as for cases where the ordinary seasonal flow regime and flood regime must be determined.

5.2.2.2. Hydro-biological or habitat simulation methodologies: through Habitat Simulation Models (PHABSIM - Physical Habitat Simulation System) physical habitat and changes in function of flow are projected; thus the habitat preferences of species, or of one species in particular, generally a fish, are quantified and are taken as an objective, based on hydraulic variables that assist in determining the connectivity of rivers, their inundations and channel capacities. Subsequently, flows are identified for the complete reproductive cycle of the selected species in order to establish an acceptable habitat (scenarios) for the selected species or for the desired environmental objective. (NORMATIVE APPENDIX E).

These methodologies are developed in a specific segment, whose selection should be subject to their ecological and hydrological representativity, their accessibility, the availability of information, and its potential for extrapolation to the basin or management unit.

5.2.2.3. Holistic methodologies: These are currently recognized for their versatility and as a methodology for integrating knowledge in order to understand the processes and hydrological regime functions, and associate them with a proposed ecological flow regime. The best known methodologies are: the Building Block Methodology (BBM) (King et al, 1998 and 2000), Downstream Response to Imposed Flow Transformation. (DRIFT) (King et al, 2003), Terms of Reference (Benchmarking) (Arthington et al, 1998 and 2006) and, Ecological Limits of Hydrologic Alteration (ELOHA) (Apse et al, 2009).

The determination of ecological flow through any holistic ecological methodology should generate fundamental proposals, taking into account the particular characteristics of the areas studied, particularly to identify the ecological significance of the different components of the hydrological regime and their relation to ecological importance and the impact on uses of water. Analyses done should allow the evaluation of conservation scenarios or presumed risk of different alternatives of water management for different the environmental objectives.

Determining the ecological flow regime by use of holistic methods is recommended for cases where it is necessary to detail the proposals of ecological flow due to the complexity, difficulty, or social or environmental conflict caused by:

- Potential conflicts between ecological flows and the other uses of water, both in quantity and seasonality;

- Areas of priority interest for conservation (Natural Protected Area, Ramsar sites, Areas of Importance for Bird Conservation (AICA) and priority sites for conservation of marine biodiversity) where the results of ecological flow predictably cause an impact on these;

- In the case of ecosystems, which because of their functional characteristics do not adequately address the determination of ecological flows through hydrological or hydro-biological methodologies (lakes, estuaries, lagoons, marshes and other wetlands);

- Feasibility studies for the development of projects;

- Reference sites in the hydrological basins where specific monitoring programs are implemented or which serve to develop knowledge of the practice of ecological flows.

Determination of the ecological flow regime through such methodologies should consider responses of the ecosystem, processes, habitat, and species to the life cycles of the natural regime. For this analysis, updated information is required through the participation of a multidisciplinary group of experts that, as a minimum, cover the following areas of knowledge: hydrology, hydraulics, geomorphology, water quality, hydrogeology, aquatic ecology, riparian vegetation, fish, macro-invertebrates, and socioeconomic aspects. The methodology and description of the minimum information that each of the disciplines involved must generate and analyze is established in NORMATIVE APPENDIX F.

The determination of flows for an ecological basin should be performed starting from reference sites, where the information for analysis will be generated for each area of knowledge. To validate the information gathered and the analysis and the recommendations of ecological flow, for each basin at least one reference site will be identified, depending on the extension of the body of water, the biodiversity, and resources. In situations of higher conflict, two sites should be selected.

As a result of this methodology, a proposal for ecological flows should be integrated, identifying each component of the altered regime, as well as which part and how much each should be modified to achieve the conservation status of the target species, based on the information provided by the knowledge areas. The proposed ecological flow shall consider a scheme for dry and average years. Furthermore, in the case of systems with infrastructure in place, flood regime and exchange rates should be specified.

To carry out further analysis in the case of an infrastructure project that represents considerable or potentially irreversible impacts to the associated hydrological regime, the level of detail reached with this type of methodologies should include:

- Hydrologic modeling;
- Habitat simulation methods;
- Scenario modeling to support decision making (hydrological, ecological and operation of infrastructure models).

In case of systems with the presence of infrastructure projects, an environmental flow proposal should be integrated for each of the components in the present system, where the possibility of alteration exists. This to identify which part of the hydrological regime will be affected and how much, based on information provided by the areas of knowledge and their predictive models. This proposal should be put forward to reach a determined state of conservation for target species and hydrological connectivity in the basin; even with the operation of a possible infrastructure project, a scheme for dry and average years should be considered. Additionally, the conditions for the flood regime and rates of change must be considered.

5.2.2.4. TABLE 4 shows the comparison of methodologies, requirements, restrictions and application recommendations.

5.3. Presentation of the study.

To systematize the results of the studies, the determination of the ecological flow regime dependent on the hydrometric stations on the upper, middle and lower parts of the basin, and at the outlet of the sub-basin, must contain the following minimum information:

1. Description of the hydrological basin.

2. Selection and characteristics of the sub-basin.

3. Ecological flows by hydrological basin.

a. Description of the methodology used, justification and preliminary determination of ecological flows;

b. Reference sites and proposed ecological flow regime.

4. Annexes. Data sheets for each reference site analyzed.

TABLE 4. Comparison of methodologies in the study of ecological flows. (A: high, M: moderate, B: low). Source: Original in King et al, 2000.

Tipo	Components Considered	Data Requirements	Level of Experience	Complexity	Resource Intensity	Resolution results	Flexibility	Cost
Hydrological	Whole ecosystem-non specific.	B-M (mainly desk studies). Historical records of virgin or naturalized flows. Use of historical ecological data.	B-M hydrologic. Some experience in ecology.	B-M	B-M	B-M	B-M	B
Hydraulic	Generic hydraulic requirements of aquatic habitat for target species.	B-M (desk and field studies). Historical flow records. Typical hydraulic discharge variables by segments. Hydraulic variables. Related to habitat flow at a generic level.	M. Hydrologic. Some hydraulic Modeling. Some experience in ecology.	B-M	B-M	B-M	B-M	B-M
Habitat simulation	Mainly habitat for target species, some consider: channel shape, transport of sediments water quality, riparian vegetation, wildlife.	M-A (desk and field studies). Historical flow records. Numerous transverse segments with multiple hydraulic variations. Suitability data of the habitat for target species.	M-A Hydrologic. Advanced level in hydraulic and habitat modeling. Specialist in ecology on physical needs of target species.	M-A	M-A	M-A	M-A	M-A
Holistic	Whole ecosystem, some consider: aquifers, wetlands, estuaries, flood plains, social dependence on the ecosystem as well as water and bank components.	M-A (desk and field studies). Flow records. Numerous transverse segments with multiple hydraulic variables. Biological data on flows and related habitat with all the requirements for biota and components of the ecosystem.	M-A Hydrologic. Advanced level in hydraulic modeling. Habitat modeling in some cases. Specialists in all ecosystem components. Some experience in socio-economic requirements.	M-A	M-A	M-A	A	M-A

NORMATIVE APPENDIX A

ENVIRONMENTAL OBJECTIVES FOR THE HYDROLOGICAL BASINS OF MEXICO.

Application The list of environmental objectives for the hydrological basins in México[1] is presented as a tool to guide the estimation of ecological flows, and reconcile the ecological importance of a basin and its pressure from use. This listing is of particular application for hydrological methodologies and a starting point to the hydro-biological and holistic assessments, where the complexity of the case or the conditions of conflict require a more detailed assessment of the environmental objective.

A.1. Inputs considered.

To qualify hydrological basins in terms of their ecological importance and pressure for water use present in each one, the following criteria were considered:

- the presence of Natural Protected Areas (Federal, State, municipal and certified);
- the presence of wetlands of international importance (Ramsar Convention);
- the presence of priority sites for conservation of epicontinental aquatic ecosystems (CONABIO-CONANP 2010);
- the pressure of use of surface and groundwater (the latter for the case of the Yucatan Peninsula) according to the availability published in the Official Journal of the Federation.

Additionally, the congruence of these criteria with the degree of potential eco-hydrological alteration of rivers and surface streams Mexico (Garrido et al. 2010) was analyzed.

A.2. List of hydrological basins and environmental objectives.

Table A.1 presents the results of this rating.

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[1] These hydrological basins refer to management units of surface water which have official water availability published in the Official Journal of the Federation, by CONAGUA.

Tabla A.1. Hydrological basins, ecological importance, pressure of use, desired state of conservation and environmental objective.

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
1	Northeast Baja California	Tijuana	Low	Very High	Deficient	D
1	Northeast Baja California	Descanso-Los Medanos	Low	Low	Good	B
1	Northeast Baja California	Guadalupe	High	Very High	Deficient	D
1	Northeast Baja California	Ensenada-El Gallo	Medium	Medium	Moderate	C
1	Northeast Baja California	San Carlos	Medium	Low	Good	B
1	Northeast Baja California	Maneadero-Las Animas	Medium	Low	Good	B
1	Northeast Baja California	Santo Tomás	Low	Low	Good	B
1	Northeast Baja California	San Vicente	Low	Low	Good	B
1	Northeast Baja California	Los Cochis - El Salado	Medium	Low	Good	B
1	Northeast Baja California	San Rafael	Medium	Low	Good	B
1	Northeast Baja California	San Telmo	Medium	High	Moderate	C
1	Northeast Baja California	Santo Domingo	Medium	Medium	Moderate	C
1	Northeast Baja California	San Quintin	Medium	Low	Good	B
1	Northeast Baja California	San Simón	High	Low	Very Good	A
1	Northeast Baja California	El Socorro	Low	Low	Good	B
1	Northeast Baja California	El Rosario	High	Low	Very Good	A
2	West Central Baja California	Santa Catarina	Medium	Low	Good	B
2	West Central Baja California	La Bocana	Medium	Low	Good	B
2	West Central Baja California	Jaraguay	Medium	Low	Good	B
2	West Central Baja California	San José	Medium	Low	Good	B
2	West Central Baja California	Chapala	Medium	Low	Good	B
2	West Central Baja California	Boca del Carrizo	Medium	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
2	West Central Baja California	San Andrés	Medium	Low	Good	B
2	West Central Baja California	Santo Dominguito	Medium	Low	Good	B
2	West Central Baja California	Rosarito	Medium	Low	Good	B
2	West Central Baja California	San Miguel	Medium	Low	Good	B
2	West Central Baja California	Paraíso	Medium	Low	Good	B
2	West Central Baja California	San Luis	High	Low	Very Good	A
2	West Central Baja California	El Arco	High	Low	Very Good	A
2	West Central Baja California	Vizcaíno	Very High	Low	Very Good	A
2	West Central Baja California	Punta Eugenia	Medium	Low	Good	B
2	West Central Baja California	San Ignacio	Very High	Low	Very Good	A
3	Southwest Baja California	Mezquital Seco	High	Low	Very Good	A
3	Southwest Baja California	Santo Domingo	High	Low	Very Good	A
3	Southwest Baja California	Bramonas	Medium	Low	Good	B
3	Southwest Baja California	La Purísima	Medium	Medium	Moderate	C
3	Southwest Baja California	Santa Rita	High	Low	Very Good	A
3	Southwest Baja California	Las Pocitas- San Hilario	High	Low	Very Good	A
3	Southwest Baja California	Conejos - Los Viejos	Low	Low	Good	B
3	Southwest Baja California	Melitón Albañez	Low	Low	Good	B
3	Southwest Baja California	La Matanza	Medium	Low	Good	B
3	Southwest Baja California	Cañada Honda	Low	Low	Good	B
3	Southwest Baja California	Pescaderos	High	Low	Very Good	A
3	Southwest Baja California	Plutarco E. Calles	Medium	Low	Good	B
3	Southwest Baja California	Migriño	Medium	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
3	Southwest Baja California	El Carrizal	Medium	Low	Good	B
3	Southwest Baja California	Todos Santos	Medium	Very High	Deficient	D
4	Northeast Baja California	Cerrada Laguna Salada	Very High	Low	Very Good	A
4	Northeast Baja California	El Borrego	Very High	Low	Very Good	A
4	Northeast Baja California	Cerrada Santa Clara	Medium	Low	Good	B
4	Northeast Baja California	Bahía San Felipe	Medium	Low	Good	B
4	Northeast Baja California	Huatamote	Medium	Low	Good	B
4	Northeast Baja California	San Fermín	Low	Low	Good	B
4	Northeast Baja California	Agua Dulce	Medium	Low	Good	B
4	Northeast Baja California	Agua Grande	Low	Low	Good	B
5	East Central Baja California	La Palma	Medium	Low	Good	B
5	East Central Baja California	Calamajue	Medium	Low	Good	B
5	East Central Baja California	Asamblea	High	Low	Very Good	A
5	East Central Baja California	Tepetate	High	Low	Very Good	A
5	East Central Baja California	San Pedro	High	Low	Very Good	A
5	East Central Baja California	Alambrado	High	Low	Very Good	A
5	East Central Baja California	El Infiernito	Medium	Low	Good	B
5	East Central Baja California	Mulege	Medium	Low	Good	B
5	East Central Baja California	San Marcos-Palo Verde	Medium	High	Moderate	C
5	East Central Baja California	San Bruno	Low	Low	Good	B
5	East Central Baja California	San Lucas	Medium	Low	Good	B
5	East Central Baja California	Santa Agueda	Medium	Very High	Deficient	D
5	East Central Baja California	Santa Rosalia	Medium	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
5	East Central Baja California	Las Vírgenes	Medium	Low	Good	B
5	East Central Baja California	Paralelo 28	Medium	Low	Good	B
6	Southeast Baja California	San Lucas	High	Low	Very Good	A
6	Southeast Baja California	San José del Cabo	Very High	Low	Very Good	A
6	Southeast Baja California	Cabo Pulmo	High	Low	Very Good	A
6	Southeast Baja California	Santiago	High	Low	Very Good	A
6	Southeast Baja California	San Bartolo	Medium	Low	Good	B
6	Southeast Baja California	Los Planes	Medium	Low	Good	B
6	Southeast Baja California	La Paz	Medium	Medium	Moderate	C
6	Southeast Baja California	El Coyote	Medium	Low	Good	B
6	Southeast Baja California	Alfredo B. Bonfil	Medium	Low	Good	B
6	Southeast Baja California	Tepentu	Medium	Low	Good	B
6	Southeast Baja California	Loreto	High	Low	Very Good	A
6	Southeast Baja California	San Juan B. Londo	High	Low	Very Good	A
6	Southeast Baja California	Rosarito	Medium	Low	Good	B
6	Southeast Baja California	Bahía Concepción	Medium	Low	Good	B
7	Colorado River	Río Colorado	Very High	Very High	Moderate	C
8	North Sonora	Arroyo Cocospera	High	Very High	Deficient	D
8	North Sonora	Río Concepción	Medium	Very High	Deficient	D
8	North Sonora	Río Magdalena	Medium	Very High	Deficient	D
8	North Sonora	Río Sonoyta 1	High	Very High	Deficient	D
8	North Sonora	Río Sonoyta 2	Medium	Very High	Deficient	D
9	South Sonora	Río Bavispe	Very High	Very High	Moderate	C

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
9	South Sonora	Río Yaqui 1	High	Very High	Deficient	D
9	South Sonora	Río Yaqui 2	Medium	Very High	Deficient	D
9	South Sonora	Río Yaqui 3	Very High	Very High	Moderate	C
9	South Sonora	Río Mayo 1	Medium	Low	Good	B
9	South Sonora	Arroyo Quiriego	Medium	Low	Good	B
9	South Sonora	Río Mayo 2	Medium	Very High	Deficient	D
9	South Sonora	Río Mayo 3	High	Very High	Deficient	D
9	South Sonora	Río Mátape 1	Medium	Medium	Moderate	C
9	South Sonora	Río Mátape 2	Very High	High	Good	B
9	South Sonora	Arroyo Cocoraque 1	Low	Medium	Moderate	C
9	South Sonora	Arroyo Cocoraque 2	Medium	Low	Good	B
9	South Sonora	Río Sonora 1	High	Very High	Deficient	D
9	South Sonora	Río San Miguel	Medium	Very High	Deficient	D
9	South Sonora	Río Sonora 2	High	Very High	Deficient	D
9	South Sonora	Río Sonora 3	High	Very High	Deficient	D
10	Sinaloa	Río Fuerte 1	High	Very High	Deficient	D
10	Sinaloa	Arroyo Alamos	High	Low	Very Good	A
10	Sinaloa	Río Fuerte 2	Very High	Very High	Moderate	C
10	Sinaloa	Río Choix	Low	Low	Good	B
10	Sinaloa	Arroyo Ocoroni	Low	High	Deficient	D
10	Sinaloa	Río Sinaloa 1	Medium	Very High	Deficient	D
10	Sinaloa	Río Sinaloa 2	High	Very High	Deficient	D
10	Sinaloa	Arroyo Cabrera	Low	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
10	Sinaloa	Río Mocorito 1	Medium	Very High	Deficient	D
10	Sinaloa	Río Mocorito 2	Medium	Very High	Deficient	D
10	Sinaloa	Río Culiacán	High	Very High	Deficient	D
10	Sinaloa	Río Humaya	Medium	Very High	Deficient	D
10	Sinaloa	Río Tamazula	Low	Very High	Deficient	D
10	Sinaloa	Río San Lorenzo 1	High	Medium	Good	B
10	Sinaloa	Río San Lorenzo 2	Medium	Very High	Deficient	D
10	Sinaloa	Río Habitas	High	High	Moderate	C
10	Sinaloa	Río Piaxtla 1	Medium	Low	Good	B
10	Sinaloa	Río Piaxtla 2	Very High	Low	Very Good	A
10	Sinaloa	Río Elota	High	Very High	Deficient	D
10	Sinaloa	Río Quelite 1	Low	Low	Good	B
10	Sinaloa	Río Quelite 2	High	Low	Very Good	A
10	Sinaloa	Río Pericos 2	Medium	Low	Good	B
10	Sinaloa	Río Pericos 1	Low	Low	Good	B
11	Presidio-San Pedro	Laguna de Santiaguillo	Medium	Very High	Deficient	D
11	Presidio-San Pedro	Río La Sauceda	Medium	Very High	Deficient	D
11	Presidio-San Pedro	La Tapona	Medium	Low	Good	B
11	Presidio-San Pedro	Río Durango	High	High	Moderate	C
11	Presidio-San Pedro	Río El Tunal	Medium	Medium	Moderate	C
11	Presidio-San Pedro	Río Presidio 1	Medium	Low	Good	B
11	Presidio-San Pedro	Río Poanas	Medium	Very High	Deficient	D
11	Presidio-San Pedro	Río San Pedro-Mezquital	High	Low	Very Good	A

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
11	Presidio-San Pedro	Río Santiago Bayacora	Medium	Very High	Deficient	D
11	Presidio-San Pedro	Río Acaponeta 1	High	Low	Very Good	A
11	Presidio-San Pedro	Río Graseros	Medium	Low	Good	B
11	Presidio-San Pedro	Río Baluarte 1	Medium	Low	Good	B
11	Presidio-San Pedro	Río Suchil	Medium	High	Moderate	C
11	Presidio-San Pedro	Río Presidio 2	Medium	Low	Good	B
11	Presidio-San Pedro	Río Baluarte 2	High	Low	Very Good	A
11	Presidio-San Pedro	Río Cañas 1	Medium	Low	Good	B
11	Presidio-San Pedro	Río Cañas 2	Medium	Low	Good	B
11	Presidio-San Pedro	Río Acaponeta 2	High	Low	Very Good	A
11	Presidio-San Pedro	Río San Pedro-Desembocadura	Very High	Low	Very Good	A
11	Presidio-San Pedro	Rosa Morada 1	Low	Low	Good	B
11	Presidio-San Pedro	Río Bejuco 1	Medium	Low	Good	B
11	Presidio-San Pedro	Rosa Morada 2	High	Low	Very Good	A
11	Presidio-San Pedro	Río Bejuco 2	Low	Low	Good	B
12	Lerma-Chapala	Lago de Pátzcuaro	High	Very High	Deficient	D
12	Lerma-Santiago	Río San Pedro	Medium	Very High	Deficient	D
12	Lerma-Santiago	Presa Calles	Medium	Very High	Deficient	D
12	Lerma-Santiago	Presa El Niágara	High	Very High	Deficient	D
12	Lerma-Santiago	Presa El Cuarenta	High	Very High	Deficient	D
12	Lerma-Santiago	Río de Lagos	High	Very High	Deficient	D
12	Lerma-Santiago	Presa Ajojucar	Medium	Very High	Deficient	D
12	Lerma-Santiago	Río Grande	Low	Very High	Deficient	D

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
12	Lerma-Santiago	Río Aguascalientes	Low	High	Deficient	D
12	Lerma-Santiago	Río San Miguel	Low	High	Deficient	D
12	Lerma-Santiago	Río del Valle	Low	Very High	Deficient	D
12	Lerma-Santiago	Río Verde 1	Medium	Very High	Deficient	D
12	Lerma-Santiago	Río Verde 2	Medium	Medium	Moderate	C
12	Lerma-Santiago	Río Palomas	Medium	Very High	Deficient	D
12	Lerma-Santiago	Río Juchipila 1	Medium	Very High	Deficient	D
12	Lerma-Santiago	Río Juchipila 3	Medium	Low	Good	B
12	Lerma-Santiago	Río Encarnación	High	Very High	Deficient	D
12	Lerma-Santiago	Río Tlaltenango	Medium	Very High	Deficient	D
12	Lerma-Santiago	Río Bolaños 2	Medium	Low	Good	B
12	Lerma-Santiago	Río San Juan	High	Low	Very Good	A
12	Lerma-Santiago	Río Atengo	High	Low	Very Good	A
12	Lerma-Santiago	Río Santiago 5	Very High	Very High	Moderate	C
12	Lerma-Santiago	Río Santiago 1	High	Very High	Deficient	D
12	Lerma-Santiago	Río Jesús María	High	Low	Very Good	A
12	Lerma-Santiago	Río Huaynamota	High	Low	Very Good	A
12	Lerma-Santiago	Río Santiago 3	High	Low	Very Good	A
12	Lerma-Santiago	Río Santiago 4	High	Low	Very Good	A
12	Lerma-Santiago	Río Santiago 2	High	Very High	Deficient	D
12	Lerma-Santiago	Presa Santa Rosa	High	Very High	Deficient	D
12	Lerma-Santiago	Río Bolaños 1	High	Medium	Good	B
12	Lerma-Santiago	Arroyo Lobatos	Medium	High	Moderate	C

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
12	Lerma-Santiago	Río Tepetongo	High	Very High	Deficient	D
12	Lerma-Santiago	Presa El Chique	High	Very High	Deficient	D
12	Lerma-Santiago	Río Juchipila 2	High	Medium	Good	B
12	Lerma-Santiago	Laguna de Zapotlán	High	Very High	Deficient	D
12	Lerma-Chapala	Río Lerma 1	Very High	Very High	Moderate	C
12	Lerma-Chapala	Río La Gavia	Medium	Very High	Deficient	D
12	Lerma-Chapala	Río La Laja 1	High	Very High	Deficient	D
12	Lerma-Chapala	Río Lerma 5	High	Very High	Deficient	D
12	Lerma-Chapala	Río Turbio	High	Very High	Deficient	D
12	Lerma-Chapala	Río Querétaro	Medium	Very High	Deficient	D
12	Lerma-Chapala	Río Zula	Medium	Very High	Deficient	D
12	Lerma-Chapala	Río La Laja 2	Medium	Very High	Deficient	D
12	Lerma-Chapala	Río Lerma 7	High	Very High	Deficient	D
12	Lerma-Chapala	Río Lerma 4	High	Very High	Deficient	D
12	Lerma-Chapala	Río Lerma 6	Medium	Very High	Deficient	D
12	Lerma-Chapala	Laguna de Yuríria	High	Very High	Deficient	D
12	Lerma-Chapala	Río Lerma 3	Medium	Very High	Deficient	D
12	Lerma-Chapala	Río Lerma 2	High	Very High	Deficient	D
12	Lerma-Chapala	Río Angulo	High	Very High	Deficient	D
12	Lerma-Chapala	Río Duero	High	Very High	Deficient	D
12	Lerma-Chapala	Río Jaltepec	Medium	Very High	Deficient	D
12	Lerma-Chapala	Lago de Cuitzeo	Very High	Very High	Moderate	C
12	Lerma-Santiago	Laguna San Marcos-Zacoalco	Low	Very High	Deficient	D

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
12	Lerma-Santiago	Laguna Villa Corona A	Medium	Very High	Deficient	D
12	Lerma-Santiago	Laguna Villa Corona B	Medium	Very High	Deficient	D
12	Lerma-Santiago	Laguna de Sayula A	Low	Very High	Deficient	D
12	Lerma-Santiago	Laguna de Sayula B	High	Very High	Deficient	D
13	Río Huicicila	Pitillal	Medium	Low	Good	B
13	Río Huicicila	Cuale	Low	Low	Good	B
13	Río Huicicila	San Blas	Very High	Medium	Very Good	A
13	Río Huicicila	Ixtapa	Medium	Medium	Moderate	C
13	Río Huicicila	Huicicila	High	Low	Very Good	A
13	Río Huicicila	Tecomala	Medium	Low	Good	B
14	Ameca River	Ahuacatlán	Medium	Medium	Moderate	C
14	Ameca River	Ameca Ixtapa A	High	Low	Very Good	A
14	Ameca River	Salado	Very High	Medium	Very Good	A
14	Ameca River	Ameca Pijinto	High	Low	Very Good	A
14	Ameca River	Cocula	High	Medium	Good	B
14	Ameca River	Talpa	Low	Low	Good	B
14	Ameca River	Atenguillo	High	Low	Very Good	A
14	Ameca River	Mascota	High	Low	Very Good	A
14	Ameca River	Ameca Ixtapa B	Medium	Low	Good	B
15	Coast of Jalisco	Río Purificación	Very High	Low	Very Good	A
15	Coast of Jalisco	Río María García	Medium	Very High	Deficient	D
15	Coast of Jalisco	Río Marabasco B	Medium	Very High	Deficient	D
15	Coast of Jalisco	Río Marabasco A	Very High	Medium	Very Good	A

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
15	Coast of Jalisco	Río Cuitzmala	High	Low	Very Good	A
15	Coast of Jalisco	Río Tecolotán	Medium	Low	Good	B
15	Coast of Jalisco	Río Ipala	High	Low	Very Good	A
15	Coast of Jalisco	Río San Nicolas B	High	Low	Very Good	A
15	Coast of Jalisco	Río San Nicolas A	Very High	Low	Very Good	A
15	Coast of Jalisco	Río Tomatlán A	Medium	High	Moderate	C
15	Coast of Jalisco	Río Tomatlán B	High	High	Moderate	C
16	Armaría-Coahuayana	Tacotan	High	Very High	Deficient	D
16	Armaría-Coahuayana	Canoas	Medium	High	Moderate	C
16	Armaría-Coahuayana	El Rosario	High	High	Moderate	C
16	Armaría-Coahuayana	Corcovado	High	Very High	Deficient	D
16	Armaría-Coahuayana	Las Piedras	High	Very High	Deficient	D
16	Armaría-Coahuayana	Armería	High	Very High	Deficient	D
16	Armaría-Coahuayana	Coahuayana-Jalisco	High	Low	Very Good	A
16	Armaría-Coahuayana	Coahuayana-Colima	High	Medium	Good	B
16	Armaría-Coahuayana	Coahuayana-Michoacán	High	Very High	Deficient	D
16	Armaría-Coahuayana	Quito	Medium	Medium	Moderate	C
17	Coast of Michoacan	Ríos Aquila-ostuta	High	Low	Very Good	A
17	Coast of Michoacan	Ríos Marmeyera-Tupitina	High	Low	Very Good	A
17	Coast of Michoacan	Río Coalcomán	High	Low	Very Good	A
17	Coast of Michoacan	Río Nexpa	Medium	Low	Good	B
17	Coast of Michoacan	Río Acapilcan	Medium	Low	Good	B
17	Coast of Michoacan	Río Chula	Medium	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
18	Balsas	Río Bajo Balsas	Very High	Very High	Moderate	C
18	Balsas	Río Tepalcatepec	High	Very High	Deficient	D
18	Balsas	Río Paracho-Nahuatzen	Medium	Very High	Deficient	D
18	Balsas	Río Cupatitzio	High	Very High	Deficient	D
18	Balsas	Río Tacámbaro	High	Very High	Deficient	D
18	Balsas	Río Zirahuen	Low	Very High	Deficient	D
18	Balsas	Río Cutzamala	High	Very High	Deficient	D
18	Balsas	Río Medio Balsas	High	Very High	Deficient	D
18	Balsas	Río Amacuzac	Very High	Very High	Moderate	C
18	Balsas	Río Bajo Atoyac	High	Very High	Deficient	D
18	Balsas	Río Nexapa	High	Very High	Deficient	D
18	Balsas	Río Alto Atoyac	Very High	Very High	Moderate	C
18	Balsas	Río Libres Oriental	High	Very High	Deficient	D
18	Balsas	Río Mixteco	High	Very High	Deficient	D
18	Balsas	Río Tlapaneco	High	Very High	Deficient	D
19	Costa Grande of Guerrero	Río Cofradía	Low	Low	Good	B
19	Costa Grande of Guerrero	Río Pontla	Medium	Low	Good	B
19	Costa Grande of Guerrero	Laguna de Coyuca	Medium	Medium	Moderate	C
19	Costa Grande of Guerrero	Río Ixtapa 1	Medium	Low	Good	B
19	Costa Grande of Guerrero	Río Ixtapa 2	Low	Low	Good	B
19	Costa Grande of Guerrero	Río San Jeronimito	Low	Low	Good	B
19	Costa Grande of Guerrero	Río Petatlán 1	Low	Low	Good	B
19	Costa Grande of Guerrero	Río Tule	Low	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
19	Costa Grande of Guerrero	Río Petatlán 2	Low	Low	Good	B
19	Costa Grande of Guerrero	Río Zihuatanejo	Low	Low	Good	B
19	Costa Grande of Guerrero	Río Coyuquilla 2	Low	Low	Good	B
19	Costa Grande of Guerrero	Río Coyuquilla 1	Low	Low	Good	B
19	Costa Grande of Guerrero	Río San Luis 1	Low	Low	Good	B
19	Costa Grande of Guerrero	Río Tecpan 2	Medium	Low	Good	B
19	Costa Grande of Guerrero	Río Tecpan 1	High	Low	Very Good	A
19	Costa Grande of Guerrero	Río El Tular	Low	Low	Good	B
19	Costa Grande of Guerrero	Río Atoyac 1	Low	Low	Good	B
19	Costa Grande of Guerrero	Río La Sabana 1	Low	Low	Good	B
19	Costa Grande of Guerrero	Río La Sabana 2	Medium	Low	Good	B
19	Costa Grande of Guerrero	Río Porvenir	Medium	Low	Good	B
19	Costa Grande of Guerrero	Río San Luis 2	Low	Low	Good	B
19	Costa Grande of Guerrero	Laguna de Nuxco	Low	Low	Good	B
19	Costa Grande of Guerrero	Río Atoyac 2	Medium	Low	Good	B
19	Costa Grande of Guerrero	Río Coyuca 1	Medium	Low	Good	B
19	Costa Grande of Guerrero	Río Coyuca 2	Low	Low	Good	B
19	Costa Grande of Guerrero	Arroyo Cacaluta	Low	Low	Good	B
19	Costa Grande of Guerrero	Río La Unión 1	Low	Low	Good	B
19	Costa Grande of Guerrero	Río La Unión 2	Low	Low	Good	B
20	Costa Chica of Guerrero	Río Petaquillas	Low	Very High	Deficient	D
20	Costa Chica of Guerrero	Río Papagayo 3	Low	Low	Good	B
20	Costa Chica of Guerrero	Río Papagayo 4	Low	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
20	Costa Chica of Guerrero	Río Cortés	Low	Very High	Deficient	D
20	Costa Chica of Guerrero	Río Nexpa 1	Low	Medium	Moderate	C
20	Costa Chica of Guerrero	Río Nexpa 2	Low	Low	Good	B
20	Costa Chica of Guerrero	Río Copala	Low	Low	Good	B
20	Costa Chica of Guerrero	Río Omitlán	Medium	High	Moderate	C
20	Costa Chica of Guerrero	Río Quetzala	High	Low	Very Good	A
20	Costa Chica of Guerrero	Río Atoyac-Tlapacoyan	High	Medium	Good	B
20	Costa Chica of Guerrero	Río Atoyac-Salado	High	Medium	Good	B
20	Costa Chica of Guerrero	Río Verde	High	Low	Very Good	A
20	Costa Chica of Guerrero	Río Atoyac-Paso de la Reina	Medium	Low	Good	B
20	Costa Chica of Guerrero	Río La Arena 2	Low	Low	Good	B
20	Costa Chica of Guerrero	Río La Arena 1	Low	Low	Good	B
20	Costa Chica of Guerrero	Río Sordo-Yolotepec	High	Low	Very Good	A
20	Costa Chica of Guerrero	Río Papagayo 1	High	Low	Very Good	A
20	Costa Chica of Guerrero	Río Papagayo 2	Low	High	Deficient	D
20	Costa Chica of Guerrero	Río Cortijos 1	Low	Low	Good	B
20	Costa Chica of Guerrero	Río Ometepec 3	Low	Low	Good	B
20	Costa Chica of Guerrero	Río Cortijos 4	Low	Low	Good	B
20	Costa Chica of Guerrero	Río Ometepec 2	Low	Medium	Moderate	C
20	Costa Chica of Guerrero	Río Ometepec 4	High	Low	Very Good	A
20	Costa Chica of Guerrero	Río Cortijos 3	Low	Low	Good	B
20	Costa Chica of Guerrero	Río Cortijos 2	Low	Low	Good	B
20	Costa Chica of Guerrero	Río Sta Catarina	Medium	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
20	Costa Chica of Guerrero	Río Infiernillo	Low	Low	Good	B
20	Costa Chica of Guerrero	Río Ometepec 1	Medium	Low	Good	B
20	Costa Chica of Guerrero	Río Marquelia 1	Low	Low	Good	B
20	Costa Chica of Guerrero	Río Marquelia 2	Low	Low	Good	B
20	Costa Chica of Guerrero	Río La Arena 3	High	Low	Very Good	A
20	Costa Chica of Guerrero	Laguna de Corralero	Medium	Low	Good	B
21	Coast of Oaxaca	Río San Francisco	High	Low	Very Good	A
21	Coast of Oaxaca	Río Grande	Low	Low	Good	B
21	Coast of Oaxaca	Río Minialtepec	Low	Low	Good	B
21	Coast of Oaxaca	Río Colotepec 1	Medium	Low	Good	B
21	Coast of Oaxaca	Río Colotepec 2	Low	Low	Good	B
21	Coast of Oaxaca	Río Cozoaltepec 2	Medium	Low	Good	B
21	Coast of Oaxaca	Río Cozoaltepec 1	Low	Low	Good	B
21	Coast of Oaxaca	Río Tonameca 2	Medium	Low	Good	B
21	Coast of Oaxaca	Río Tonameca 1	Medium	Low	Good	B
21	Coast of Oaxaca	Río Coyula	High	Low	Very Good	A
21	Coast of Oaxaca	Río Copalita 1	Very High	Low	Very Good	A
21	Coast of Oaxaca	Río Copalita 2	High	Low	Very Good	A
21	Coast of Oaxaca	Río Zimatán 1	Low	Low	Good	B
21	Coast of Oaxaca	Río Zimatán 2	High	Low	Very Good	A
21	Coast of Oaxaca	Río Ayuta 1	Medium	Low	Good	B
21	Coast of Oaxaca	Río Ayuta 2	Medium	Low	Good	B
21	Coast of Oaxaca	Río Astata 1	Low	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
21	Coast of Oaxaca	Río Mazatán	Medium	Low	Good	B
21	Coast of Oaxaca	Río Astata 2	Low	Low	Good	B
22	Tehuantepec	Río Los Perros 1	Medium	Low	Good	B
22	Tehuantepec	Río Espíritu Santo 1	Medium	Low	Good	B
22	Tehuantepec	Río Niltepec 1	Low	Low	Good	B
22	Tehuantepec	Río Ostuta 1	Low	Low	Good	B
22	Tehuantepec	Río Zanatepec	Low	Low	Good	B
22	Tehuantepec	Río Ostuta 2	Low	Low	Good	B
22	Tehuantepec	Río Niltepec 2	Low	Low	Good	B
22	Tehuantepec	Río Cazadero	Low	Low	Good	B
22	Tehuantepec	Río Espíritu Santo 2	Medium	Medium	Moderate	C
22	Tehuantepec	Río Estancado	Medium	Low	Good	B
22	Tehuantepec	Río Los Perros 2	Low	High	Deficient	D
22	Tehuantepec	Río San Antonio	Medium	Very High	Deficient	D
22	Tehuantepec	Río Tequisistlán	High	Medium	Good	B
22	Tehuantepec	Río Tehuantepec 2	Low	Very High	Deficient	D
22	Tehuantepec	Río Tehuantepec 1	High	Very High	Deficient	D
23	Coast of Chiapas	La Punta	High	Low	Very Good	A
23	Coast of Chiapas	Puerto Madero	High	Medium	Good	B
23	Coast of Chiapas	Cozoloapan	High	Medium	Good	B
23	Coast of Chiapas	Laguna Mar Muerto A.	Medium	Low	Good	B
23	Coast of Chiapas	Laguna del Viejo y Temblader	High	Low	Very Good	A
23	Coast of Chiapas	Tapanatepec	Medium	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
23	Coast of Chiapas	Laguna Mar Muerto B	Medium	Low	Good	B
23	Coast of Chiapas	Las Arenas	High	Low	Very Good	A
23	Coast of Chiapas	El Porvenir	Medium	Low	Good	B
23	Coast of Chiapas	San Diego	High	Low	Very Good	A
23	Coast of Chiapas	Margaritas y Coapa	High	Low	Very Good	A
23	Coast of Chiapas	Novillero Alto	High	Low	Very Good	A
23	Coast of Chiapas	Cacaluta	High	Low	Very Good	A
23	Coast of Chiapas	Despoblado	Very High	Low	Very Good	A
23	Coast of Chiapas	Huixtla	High	Low	Very Good	A
23	Coast of Chiapas	Huehuetán	High	Medium	Good	B
23	Coast of Chiapas	Cahuacán	High	Low	Very Good	A
23	Coast of Chiapas	Coatán	High	Medium	Good	B
23	Coast of Chiapas	Pijijiapan	High	Low	Very Good	A
23	Coast of Chiapas	Sesecapa	High	Low	Very Good	A
23	Coast of Chiapas	Suchiate	High	Low	Very Good	A
23	Coast of Chiapas	Sanatenco	High	Low	Very Good	A
23	Coast of Chiapas	Laguna Mar Muerto C	High	Low	Very Good	A
23	Coast of Chiapas	Laguna de la Joya	High	Low	Very Good	A
23	Coast of Chiapas	Jesús	High	Low	Very Good	A
24	Bravo-Conchos	Río Bravo 13	High	Very High	Deficient	D
24	Bravo-Conchos	Río Bravo 11	Medium	Very High	Deficient	D
24	Bravo-Conchos	Río Florido 1	Medium	Very High	Deficient	D
24	Bravo-Conchos	Río Florido 2	Medium	Very High	Deficient	D

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
24	Bravo-Conchos	Río Balleza	Low	Very High	Deficient	D
24	Bravo-Conchos	Río Florido 3	Medium	Very High	Deficient	D
24	Bravo-Conchos	Río Parral	Low	Very High	Deficient	D
24	Bravo-Conchos	Río Conchos 1	High	Very High	Deficient	D
24	Bravo-Conchos	Río Conchos 2	High	Very High	Deficient	D
24	Bravo-Conchos	Río Conchos 3	Medium	Very High	Deficient	D
24	Bravo-Conchos	Río Conchos 4	Low	Very High	Deficient	D
24	Bravo-Conchos	Río San Pedro	Medium	Very High	Deficient	D
24	Bravo-Conchos	Río Chuviscar	Medium	Very High	Deficient	D
24	Bravo-Conchos	Río Bravo 3	High	Very High	Deficient	D
24	Bravo-Conchos	Río Bravo 4	High	Very High	Deficient	D
24	Bravo-Conchos	Río Bravo 5	High	Very High	Deficient	D
24	Bravo-Conchos	Río Bravo 6	Low	Very High	Deficient	D
24	Bravo-Conchos	Arroyo de las Vacas	Medium	Very High	Deficient	D
24	Bravo-Conchos	Río San Diego	Medium	Very High	Deficient	D
24	Bravo-Conchos	Río Bravo 7	Low	Very High	Deficient	D
24	Bravo-Conchos	Río San Rodrigo	High	Very High	Deficient	D
24	Bravo-Conchos	Río Bravo 8	Low	Very High	Deficient	D
24	Bravo-Conchos	Río Escondido	High	Very High	Deficient	D
24	Bravo-Conchos	Río Bravo 9	High	Very High	Deficient	D
24	Bravo-Conchos	Río Bravo 10	High	Very High	Deficient	D
24	Bravo-Conchos	Río Sabinas	Very High	Very High	Moderate	C
24	Bravo-Conchos	Río San Juan 2	High	Very High	Deficient	D

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
24	Bravo-Conchos	Río San Juan 3	Medium	Very High	Deficient	D
24	Bravo-Conchos	Río Nadadores	Very High	Very High	Moderate	C
24	Bravo-Conchos	Río Bravo 12	Medium	Very High	Deficient	D
24	Bravo-Conchos	Río Álamo	High	Very High	Deficient	D
24	Bravo-Conchos	Río Salado	Very High	Very High	Moderate	C
24	Bravo-Conchos	Río Pesquería	High	Very High	Deficient	D
24	Bravo-Conchos	Río San Juan 1	High	Very High	Deficient	D
24	Bravo-Conchos	Río Salinas	Medium	Very High	Deficient	D
24	Bravo-Conchos	Bravo 1	Medium	Very High	Deficient	D
24	Bravo-Conchos	Bravo 2	Low	Very High	Deficient	D
25	San Fernando-Soto La Marina	Río Soto La Marina 2	Medium	Low	Good	B
25	San Fernando-Soto La Marina	Río Soto La Marina 1	Medium	Very High	Deficient	D
25	San Fernando-Soto La Marina	Río Soto La Marina 3	Medium	Low	Good	B
25	San Fernando-Soto La Marina	Río Palmas	Medium	Low	Good	B
25	San Fernando-Soto La Marina	Río San Lorenzo	Medium	Low	Good	B
25	San Fernando-Soto La Marina	Río San Fernando 1	High	Very High	Deficient	D
25	San Fernando-Soto La Marina	Río Conchos	Medium	Very High	Deficient	D
25	San Fernando-Soto La Marina	Arroyo Burgos	Low	Low	Good	B
25	San Fernando-Soto La Marina	Río Potosí 1	High	Very High	Deficient	D
25	San Fernando-Soto La Marina	Río Potosí 2	Low	Very High	Deficient	D
25	San Fernando-Soto La Marina	Río San Fernando 2	Very High	Low	Very Good	A
25	San Fernando-Soto La Marina	Río Pablillo 2	Low	Very High	Deficient	D
25	San Fernando-Soto La Marina	Arroyo Los Anegados o Conchos	Medium	Very High	Deficient	D

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
25	San Fernando-Soto La Marina	Río Camacho	Low	Very High	Deficient	D
25	San Fernando-Soto La Marina	Río Pablillo 1	Medium	Very High	Deficient	D
25	San Fernando-Soto La Marina	Arroyo Chorreras o Las Norias	Low	Low	Good	B
25	San Fernando-Soto La Marina	Laguna Madre Norte	Very High	Low	Very Good	A
25	San Fernando-Soto La Marina	Arroyos Chapote-Temascal	Medium	Low	Good	B
25	San Fernando-Soto La Marina	Arroyos La Misión-Santa Rosa	Medium	Low	Good	B
25	San Fernando-Soto La Marina	Arroyos Olivares-Paxtle	Medium	Low	Good	B
25	San Fernando-Soto La Marina	Arroyos Calanche-Venados	Medium	Low	Good	B
25	San Fernando-Soto La Marina	Barra Jesús María	Very High	Low	Very Good	A
25	San Fernando-Soto La Marina	Laguna Morales	Medium	Low	Good	B
25	San Fernando-Soto La Marina	Tepehuajes	Medium	Low	Good	B
25	San Fernando-Soto La Marina	Río San Rafael 1	Low	Very High	Deficient	D
25	San Fernando-Soto La Marina	Río San Rafael 2	Low	Medium	Moderate	C
25	San Fernando-Soto La Marina	Barra Carrizos	High	Low	Very Good	A
25	San Fernando-Soto La Marina	Barra de San Vicente	Low	Low	Good	B
25	San Fernando-Soto La Marina	Río San Rafael 3	Low	Low	Good	B
25	San Fernando-Soto La Marina	Río Barberena 1	Medium	Low	Good	B
25	San Fernando-Soto La Marina	Río Tigre 1	Low	Low	Good	B
25	San Fernando-Soto La Marina	Río Tigre 2	Low	Low	Good	B
25	San Fernando-Soto La Marina	Río Barberena 2	Low	Low	Good	B
25	San Fernando-Soto La Marina	Laguna Las Marismas	Low	Low	Good	B
25	San Fernando-Soto La Marina	Barra de Ostiones	Medium	Low	Good	B
25	San Fernando-Soto La Marina	Laguna de San Andrés	Low	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
25	San Fernando-Soto La Marina	Río San Marcos y arroyos San Carlos, Las Puentes, Sarnoso y El Moro	High	Very High	Deficient	D
25	San Fernando-Soto La Marina	Río Pilón 1	Low	Very High	Deficient	D
25	San Fernando-Soto La Marina	Río Pilón 2	Medium	Very High	Deficient	D
25	San Fernando-Soto La Marina	Río Blanco	Medium	Very High	Deficient	D
25	San Fernando-Soto La Marina	Río San Antonio	Low	Very High	Deficient	D
25	San Fernando-Soto La Marina	Río Purificación 1	Low	Very High	Deficient	D
25	San Fernando-Soto La Marina	Río Purificación 2	Low	Very High	Deficient	D
25	San Fernando-Soto La Marina	Río Corona	Medium	Very High	Deficient	D
25	San Fernando-Soto La Marina	Arroyo Grande	Low	Very High	Deficient	D
26	Pánuco	Río Moctezuma 1	Medium	High	Moderate	C
26	Pánuco	Embalse Zimapán	Low	Very High	Deficient	D
26	Pánuco	Río Jaumave-Chihue	Medium	Very High	Deficient	D
26	Pánuco	Río Sabinas	Medium	Low	Good	B
26	Pánuco	Río Guayalejo 3	High	High	Moderate	C
26	Pánuco	Río Comandante 1	High	Medium	Good	B
26	Pánuco	Arroyo el Cojo	Medium	Medium	Moderate	C
26	Pánuco	Río Guayalejo 4	High	High	Moderate	C
26	Pánuco	Río Comandante 2	Medium	Low	Good	B
26	Pánuco	Río Valles	High	High	Moderate	C
26	Pánuco	Río El Salto	High	Low	Very Good	A
26	Pánuco	Río Verde 2	High	Very High	Deficient	D
26	Pánuco	Río Mante	Low	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
26	Pánuco	Río Tamesí	High	Medium	Good	B
26	Pánuco	Río Tantoán	Medium	Low	Good	B
26	Pánuco	Río Verde 1	High	High	Moderate	C
26	Pánuco	Río Gallinas	Low	Low	Good	B
26	Pánuco	Río Verde 3	High	Low	Very Good	A
26	Pánuco	Río Pánuco 2	High	Low	Very Good	A
26	Pánuco	Ríos Moctezuma 5	High	Medium	Good	B
26	Pánuco	Río Pánuco 1	Medium	Low	Good	B
26	Pánuco	Río Tampaón 1	High	Low	Very Good	A
26	Pánuco	Arroyo Tamacuil o La Llave	Low	Low	Good	B
26	Pánuco	Arroyo Altamira	High	Very High	Deficient	D
26	Pánuco	Río Chicayán 2	Medium	Low	Good	B
26	Pánuco	Río Choy	Low	Medium	Moderate	C
26	Pánuco	Río Tamasopo 2	Low	Low	Good	B
26	Pánuco	Río Tamasopo 1	Low	Low	Good	B
26	Pánuco	Río Tampaón 2	Low	Medium	Moderate	C
26	Pánuco	Río Santa María 1	High	Medium	Good	B
26	Pánuco	Río Santa María 2	High	Low	Very Good	A
26	Pánuco	Río Moctezuma 4	Low	Medium	Moderate	C
26	Pánuco	Río Santa María 3	Very High	Low	Very Good	A
26	Pánuco	Río Coy 2	Low	Low	Good	B
26	Pánuco	Arroyo El Puerquito o San Bartolo	High	Very High	Deficient	D
26	Pánuco	Río Coy 1	Low	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
26	Pánuco	Río Moctezuma 3	High	Low	Very Good	A
26	Pánuco	Río Chicayán 1	High	High	Moderate	C
26	Pánuco	Río Huichihuayán	Medium	Low	Good	B
26	Pánuco	Río Tempoal 2	Medium	Low	Good	B
26	Pánuco	Río San Pedro	Low	Low	Good	B
26	Pánuco	Río Tancuilín	Medium	Low	Good	B
26	Pánuco	Río Tempoal 1	Medium	Medium	Moderate	C
26	Pánuco	Río Victoria	Medium	Medium	Moderate	C
26	Pánuco	Río Moctezuma 2	Medium	Low	Good	B
26	Pánuco	Río Claro	High	Low	Very Good	A
26	Pánuco	Río Amajac	Low	Low	Good	B
26	Pánuco	Río Extoraz	Medium	Very High	Deficient	D
26	Pánuco	Río Los Hules	High	Low	Very Good	A
26	Pánuco	Río Calabozo	Medium	Low	Good	B
26	Pánuco	Río Tolimán	Medium	Very High	Deficient	D
26	Pánuco	Río San Juan 2	Low	Very High	Deficient	D
26	Pánuco	Río San Juan 1	Medium	Very High	Deficient	D
26	Pánuco	Río Amajaque	Medium	Medium	Moderate	C
26	Pánuco	Río Metztitlán 2	High	High	Moderate	C
26	Pánuco	Río Tecozautla	Medium	Very High	Deficient	D
26	Pánuco	Río Metzquititlán	Medium	Low	Good	B
26	Pánuco	Río Metztitlán 1	High	High	Moderate	C
26	Pánuco	Arroyo Zarco	Medium	Very High	Deficient	D

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
26	Pánuco	Río Grande de Tulancingo	Medium	Very High	Deficient	D
26	Pánuco	Río Guayalejo 2	Medium	Very High	Deficient	D
26	Pánuco	Rio Guayalejo 1	Medium	Low	Good	B
26	Pánuco	Xochimilco	High	Low	Very Good	A
26	Pánuco	Río La Compañía	High	Very High	Deficient	D
26	Pánuco	Tochac-Tecocomulco	High	Very High	Deficient	D
26	Pánuco	Texcoco	Medium	Very High	Deficient	D
26	Pánuco	Ciudad de México	High	Very High	Deficient	D
26	Pánuco	Río Tula	Low	Very High	Deficient	D
26	Pánuco	Río Actopan	Medium	Very High	Deficient	D
26	Pánuco	Río Alfajayucan	Medium	Very High	Deficient	D
26	Pánuco	Río de las Avenidas de Pachuca	Medium	Very High	Deficient	D
26	Pánuco	Presa Endho	Medium	Very High	Deficient	D
26	Pánuco	Río Cuautitlán	Medium	Very High	Deficient	D
26	Pánuco	Río Salado	Medium	Very High	Deficient	D
26	Pánuco	Presa Requena	High	Very High	Deficient	D
26	Pánuco	Río Galindo	Low	Very High	Deficient	D
26	Pánuco	Río Ñado	Medium	Very High	Deficient	D
27	North of Veracruz	Río Tuxpan	Very High	Medium	Very Good	A
27	North of Veracruz	Llanuras de Tuxpan	Very High	Low	Very Good	A
27	North of Veracruz	Río Cazones	Very High	Low	Very Good	A
27	North of Veracruz	Río Tecolutla	Very High	Medium	Very Good	A
27	North of Veracruz	Río Nautla	High	Medium	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
27	North of Veracruz	Río Misantla	Low	Low	Good	B
27	North of Veracruz	Río Colipa	Low	Low	Good	B
27	North of Veracruz	Río Cucharas	Medium	Low	Good	B
27	North of Veracruz	Río Tancochín	Medium	Low	Good	B
27	North of Veracruz	Arroyo La Piedra o La Laja	Low	Low	Good	B
27	North of Veracruz	Arroyo Carbajal	High	Low	Very Good	A
27	North of Veracruz	Estero Galindo	Medium	Low	Good	B
28	Papaloapan	Llanuras de Actopan	Medium	Low	Good	B
28	Papaloapan	Río La Antigua	Very High	Medium	Very Good	A
28	Papaloapan	Río Actopan	High	High	Moderate	C
28	Papaloapan	Río Jamapa-Cotaxtla	High	Low	Very Good	A
28	Papaloapan	Río Jamapa	High	Very High	Deficient	D
28	Papaloapan	Río Cotaxtla	High	Medium	Good	B
28	Papaloapan	Río Blanco	Very High	Very High	Moderate	C
28	Papaloapan	Río Salado	High	High	Moderate	C
28	Papaloapan	Río Tonto	High	Very High	Deficient	D
28	Papaloapan	Río Papaloapan	Very High	Low	Very Good	A
28	Papaloapan	Río Valle Nacional	High	Low	Very Good	A
28	Papaloapan	Río Grande	High	Low	Very Good	A
28	Papaloapan	Río Santo Domingo	High	Very High	Deficient	D
28	Papaloapan	Río Playa Vicente	High	Low	Very Good	A
28	Papaloapan	Río Tesechoacán	High	Low	Very Good	A
28	Papaloapan	Río Trinidad	Medium	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
28	Papaloapan	Río San Juan	Very High	Low	Very Good	A
28	Papaloapan	Llanuras de Papaloapan	Very High	Low	Very Good	A
29	Coatzacoalcos	Llanuras del Coatzacoalcos	Medium	Low	Good	B
29	Coatzacoalcos	Río Huazuntlán	High	Low	Very Good	A
29	Coatzacoalcos	Bajo Río Uxpanapa	Medium	Low	Good	B
29	Coatzacoalcos	Bajo Río Coatzacoalcos	Medium	Low	Good	B
29	Coatzacoalcos	Alto Río Uxpanapa	Medium	Low	Good	B
29	Coatzacoalcos	Alto Río Coatzacoalcos	High	Low	Very Good	A
29	Coatzacoalcos	Coacajapa	Medium	Low	Good	B
29	Coatzacoalcos	Zanapa	Low	Low	Good	B
29	Coatzacoalcos	Tancochapa Alto	Low	Low	Good	B
29	Coatzacoalcos	Santa Anita	Low	Low	Good	B
29	Coatzacoalcos	Tonalá	Medium	Low	Good	B
29	Coatzacoalcos	Tancochapa Bajo	Low	Low	Good	B
29	Coatzacoalcos	Poza Crispín	Medium	Low	Good	B
29	Coatzacoalcos	Laguna Machona	Low	Low	Good	B
29	Coatzacoalcos	Laguna del Carmen	Low	Low	Good	B
30	Grijalva-Usumacinta	Papizaca	Low	Medium	Moderate	C
30	Grijalva-Usumacinta	Zacualpa	Medium	Low	Good	B
30	Grijalva-Usumacinta	Yayahuita	Medium	Low	Good	B
30	Grijalva-Usumacinta	Grande o Salinas	High	Low	Very Good	A
30	Grijalva-Usumacinta	Tzimbac	Medium	Low	Good	B
30	Grijalva-Usumacinta	Ixcan	Low	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
30	Grijalva-Usumacinta	Chajul	Low	Low	Good	B
30	Grijalva-Usumacinta	De los Plátanos	Medium	Low	Good	B
30	Grijalva-Usumacinta	Chicoasén	High	High	Moderate	C
30	Grijalva-Usumacinta	Caxcuchapa	Low	Low	Good	B
30	Grijalva-Usumacinta	Cunduacán	Low	Low	Good	B
30	Grijalva-Usumacinta	Platanar	Low	Low	Good	B
30	Grijalva-Usumacinta	Paredón	Low	Low	Good	B
30	Grijalva-Usumacinta	Presa Peñitas	Low	Very High	Deficient	D
30	Grijalva-Usumacinta	Zayula	Medium	Low	Good	B
30	Grijalva-Usumacinta	Viejo Mezcalapa	Low	Low	Good	B
30	Grijalva-Usumacinta	Almendro	Medium	Low	Good	B
30	Grijalva-Usumacinta	Puxcatán	Medium	Low	Good	B
30	Grijalva-Usumacinta	Tacotalpa	Medium	Low	Good	B
30	Grijalva-Usumacinta	De la Sierra	High	Low	Very Good	A
30	Grijalva-Usumacinta	Mamatel	Low	Low	Good	B
30	Grijalva-Usumacinta	Cumpan	High	Low	Very Good	A
30	Grijalva-Usumacinta	San Pedro	Medium	Low	Good	B
30	Grijalva-Usumacinta	Laguna del Este	Very High	Low	Very Good	A
30	Grijalva-Usumacinta	Palizada	Very High	Low	Very Good	A
30	Grijalva-Usumacinta	Laguna del Pom y Atasta	Very High	Low	Very Good	A
30	Grijalva-Usumacinta	San Pedro y San Pablo	High	Low	Very Good	A
30	Grijalva-Usumacinta	Tabasquillo	High	Low	Very Good	A
30	Grijalva-Usumacinta	Chilapilla	High	Low	Very Good	A

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
30	Grijalva-Usumacinta	Macuxpana	Medium	Low	Good	B
30	Grijalva-Usumacinta	Chilapa	Very High	Low	Very Good	A
30	Grijalva-Usumacinta	Chacamax	Very High	Low	Very Good	A
30	Grijalva-Usumacinta	Shumulá	Low	Low	Good	B
30	Grijalva-Usumacinta	Azul	Low	Low	Good	B
30	Grijalva-Usumacinta	Soyatenco	Medium	Low	Good	B
30	Grijalva-Usumacinta	Cintalapa	Medium	Medium	Moderate	C
30	Grijalva-Usumacinta	Encajonado	High	Low	Very Good	A
30	Grijalva-Usumacinta	De La Venta	Medium	Low	Good	B
30	Grijalva-Usumacinta	Presa Nezahualcoyotl	Medium	Very High	Deficient	D
30	Grijalva-Usumacinta	Suchiapa	High	Medium	Good	B
30	Grijalva-Usumacinta	Chacté	Medium	Low	Good	B
30	Grijalva-Usumacinta	Tulija	Medium	Low	Good	B
30	Grijalva-Usumacinta	Yashijá	Medium	Low	Good	B
30	Grijalva-Usumacinta	Santo Domingo	High	High	Moderate	C
30	Grijalva-Usumacinta	Comitán	High	Low	Very Good	A
30	Grijalva-Usumacinta	Santo Domingo	High	Low	Very Good	A
30	Grijalva-Usumacinta	Seco	Low	Low	Good	B
30	Grijalva-Usumacinta	Caliente	Low	Low	Good	B
30	Grijalva-Usumacinta	Euseba	Low	Low	Good	B
30	Grijalva-Usumacinta	Laguna Miramar	Medium	Low	Good	B
30	Grijalva-Usumacinta	San Pedro	High	Low	Very Good	A
30	Grijalva-Usumacinta	Perlas	Medium	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
30	Grijalva-Usumacinta	Jatate	Very High	Low	Very Good	A
30	Grijalva-Usumacinta	Tzanconeja	Medium	Low	Good	B
30	Grijalva-Usumacinta	Usumacinta	Very High	Low	Very Good	A
30	Grijalva-Usumacinta	Chocaljah	High	Low	Very Good	A
30	Grijalva-Usumacinta	Basca	Low	Low	Good	B
30	Grijalva-Usumacinta	Hondo	High	High	Moderate	C
30	Grijalva-Usumacinta	Tuxtla Gutiérrez	High	High	Moderate	C
30	Grijalva-Usumacinta	Presa Chicoasén	Very High	Very High	Moderate	C
30	Grijalva-Usumacinta	Aguacatenco	Medium	Very High	Deficient	D
30	Grijalva-Usumacinta	San Pedro	High	Medium	Good	B
30	Grijalva-Usumacinta	Lagartero	High	Medium	Good	B
30	Grijalva-Usumacinta	Samaria	Low	Low	Good	B
30	Grijalva-Usumacinta	El Carrizal	Very High	Low	Very Good	A
30	Grijalva-Usumacinta	Laguna de Términos	Very High	Low	Very Good	A
30	Grijalva-Usumacinta	Mezcalapa	Low	Low	Good	B
30	Grijalva-Usumacinta	Grijalva	Very High	Low	Very Good	A
30	Grijalva-Usumacinta	Margarítas	Low	Low	Good	B
30	Grijalva-Usumacinta	Alto Grijalva	Medium	Low	Good	B
30	Grijalva-Usumacinta	Selegua	Low	High	Deficient	D
30	Grijalva-Usumacinta	Presa La Angostura	High	Very High	Deficient	D
30	Grijalva-Usumacinta	Chapopote	High	Low	Very Good	A
30	Grijalva-Usumacinta	San Miguel	Low	Low	Good	B
30	Grijalva-Usumacinta	Aguzarca	Medium	Low	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
30	Grijalva-Usumacinta	Chixoy	Low	Low	Good	B
30	Grijalva-Usumacinta	Lacantún	Very High	Low	Very Good	A
30	Grijalva-Usumacinta	Lacanjá	Very High	Low	Very Good	A
30	Grijalva-Usumacinta	Pichucalco	High	Low	Very Good	A
30	Grijalva-Usumacinta	Bajo Río Candelaria	Very High	Low	Very Good	A
30	Grijalva-Usumacinta	Alto Río Candelaria	High	Low	Very Good	A
30	Grijalva-Usumacinta	La Concordia	Medium	Very High	Deficient	D
30	Grijalva-Usumacinta	Presa La Concordia	Medium	Very High	Deficient	D
31	West Yucatán	Río Champotón 2	Low	Low	Good	B
31	West Yucatán	Río Champotón 1	Low	Low	Good	B
33	East Yucatán	Río Escondido	High	Low	Very Good	A
34	Closed Basins of the North	Desierto de Samalayuca	High	Low	Very Good	A
34	Closed Basins of the North	Laguna El Sabinal	Low	Very High	Deficient	D
34	Closed Basins of the North	Rancho El Cuarenta	Low	Low	Good	B
34	Closed Basins of the North	Laguna de Babicora	Medium	Low	Good	B
34	Closed Basins of the North	Laguna de Bustillos	Low	Low	Good	B
34	Closed Basins of the North	Félix U Gómez	Low	Low	Good	B
34	Closed Basins of the North	Arroyo El Carrizo	Low	Low	Good	B
34	Closed Basins of the North	Arroyo El Burro	Low	Low	Good	B
34	Closed Basins of the North	Laguna de Tarabillas	Low	Low	Good	B
34	Closed Basins of the North	Laguna de Encinillas	Low	Medium	Moderate	C
34	Closed Basins of the North	Hacienda San Francisco-Juguete-Madero-Palomas	High	Low	Very Good	A

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
34	Closed Basins of the North	Río Casas Grandes 1	High	Medium	Good	B
34	Closed Basins of the North	Río del Carmen 1	Low	Low	Good	B
34	Closed Basins of the North	Río Santa María 1	Low	Very High	Deficient	D
34	Closed Basins of the North	Laguna Los Mexicanos	Low	Low	Good	B
34	Closed Basins of the North	Río Casas Grandes 2	High	Low	Very Good	A
34	Closed Basins of the North	Laguna El Cuervo	Medium	Low	Good	B
34	Closed Basins of the North	Rancho Hormigas-El Diablo	Low	Low	Good	B
34	Closed Basins of the North	Río del Carmen 2	Low	Medium	Moderate	C
34	Closed Basins of the North	Arroyo Roma	Medium	Low	Good	B
34	Closed Basins of the North	Laguna La Vieja	Low	Medium	Moderate	C
34	Closed Basins of the North	Río Santa Maria 2	Medium	Very High	Deficient	D
35	Mapimí	Valle Hundido	Medium	Low	Good	B
35	Mapimí	Laguna del Rey	High	Low	Very Good	A
35	Mapimí	Laguna del Guaje-Lipanés	High	Low	Very Good	A
35	Mapimí	Polvorillos-Arroyo El Marquez	Medium	Low	Good	B
35	Mapimí	El Llano-Laguna del Milagro	Medium	Low	Good	B
35	Mapimí	Arroyo La India-Laguna Palomas	High	High	Moderate	C
36	Nazas-Aguanaval	Nazareno	High	Medium	Good	B
36	Nazas-Aguanaval	Laguna de Viesca	Low	Low	Good	B
36	Nazas-Aguanaval	Río Sextín	Medium	Low	Good	B
36	Nazas-Aguanaval	Presa La Flor	High	Medium	Good	B
36	Nazas-Aguanaval	San Francisco	Medium	Medium	Moderate	C
36	Nazas-Aguanaval	Los Ángeles	High	Medium	Good	B

Hydrological Region Code	Name of Hydrological Region	Name of basin with availability study	Ecological importance	Pressure from use	Desired state of conservation	Environmental objective
36	Nazas-Aguanaval	Presa Leobardo Reynoso	Medium	Very High	Deficient	D
36	Nazas-Aguanaval	Presa Cazadero	Medium	Very High	Deficient	D
36	Nazas-Aguanaval	Presa Santa Rosa	Medium	Very High	Deficient	D
36	Nazas-Aguanaval	Canal Santa Rosa	High	Very High	Deficient	D
36	Nazas-Aguanaval	Arroyo Cadena	High	Low	Very Good	A
36	Nazas-Aguanaval	Laguna de Mayrán	Low	Low	Good	B
36	Nazas-Aguanaval	Río Ramos	Medium	Medium	Moderate	C
36	Nazas-Aguanaval	Presa Lázaro Cárdenas	Medium	High	Moderate	C
36	Nazas-Aguanaval	Agustín Melgar	Medium	Medium	Moderate	C
36	Nazas-Aguanaval	Presa Francisco Zarco	Medium	Medium	Moderate	C
37	El Salado	Sierra Madre Oriental	High	Medium	Good	B
37	El Salado	Sierra Rodríguez	Low	Low	Good	B
37	El Salado	Camacho-Gruñidora	Low	Medium	Moderate	C
37	El Salado	Matehuala	High	Low	Very Good	A
37	El Salado	Fresnillo-Yesca	Very High	Low	Very Good	A
37	El Salado	Sierra Madre	High	Low	Very Good	A
37	El Salado	Presa San Pablo y Otras	High	Low	Very Good	A
37	El Salado	Presa San José-Los Pilares y Otras	High	Low	Very Good	A
	Yucatan Peninsula*	Isla de Cozumel**	High	Medium	Good	B
	Yucatan Peninsula*	Cerros y Valles**	Very High	Medium	Very Good	A
	Yucatan Peninsula*	Xpujil**	Very High	Low	Very Good	A
	Yucatan Peninsula*	Peninsula de Yucatan**	Very High	Medium	Very Good	A

*Basin organism. **Aquifer.

NORMATIVE APPENDIX B

PROCEDURE TO DETERMINE THE ALTERATION OF THE NATURAL HYDROLOGICAL REGIME IN A STREAM BY PRESENCE OF INFRASTRUCTURE.

Definition

Determination of the water volume regime, on a monthly and annual basis, in natural state and present state, and the degree of impact of the latter on the former. The aim is to determine whether or not there is significant alteration of the natural hydrological regime due to the presence of hydraulic or hydroelectric infrastructure.

Application

In those segments where there are hydraulic works (e.g. large dams or diverters) or water intakes (e.g. pumping wells) affecting the natural hydrologic regime of flows and associated aquatic ecosystems. In all these cases it will be necessary to identify the degree of alteration that exists in the present hydrological regime (RHA) in relation to the natural regime (RHN).

Hydrological regime elements to be determined

Regime of monthly and annual volumes of water in the natural state and in the existing state, if there is alteration in the RHA.

Required information

The following information is required:

- A daily series, of at least 20 full years of information, for each hydrological regime (natural and extant or presumably altered). For smaller bases, the representativeness of the sample should be analyzed for the presence of wet, average, dry and very dry years.

Procedure to be followed

The procedure for determination of the hydrological alteration of a stream will be conducted, based on the monthly and annual volumes of water, as follows:

1. Identify the stream where the study of the ecological flows will be conducted.

2. From the most representative hydrometric station in the zone, determine the regime of ordinary flows (maximum and minimum) according to the procedure detailed as follows:

i. Based on hydrological data from the series, order the mean monthly flows, separating the series into RHN, and existing regime or presumably altered regime (RHA);

ii. Organize monthly flows in calendar years for both series;

iii. For each month of the year in the RHN series, calculate the 90th and 10th percentiles, both monthly and yearly.

3. Check if present flows (RHA), on a monthly and annual basis, are contained in the ordinary flow regime maximum (P90) and minimum (P10) suggested by RHN, wherein:

    - If the present regime (RHA), in monthly and annual magnitude, reaches more than 50% relative to RHN, it will be considered hydrologically unaltered.

    - If the performance of the present regime (RHA) is less 50% of monthly and annual magnitude relative to RHN, it will be deemed altered.

NORMATIVE APPENDIX

HYDROLOGICAL METHODOLOGY TO DETERMINE THE REGIME OF ECOLOGICAL FLOWS IN NATIONAL STREAMS OR BODIES OF WATER AT HYDROLOGICAL BASIN LEVEL, BASED ON THE METHOD PROPOSED BY GARCIA ET AL. (1999).

Background

The simplest hydrologic methodologies are calculated from "desktop" data. Their original and primary objective was the conservation of economically important species in perennial rivers with little seasonal variation. These methodologies are the most well-known, representing 30% of the methodologies developed.

The best known is the Tennant method (1976), also known as the Montana method. It is one of the most-used worldwide for its simple calculations and it is used basically in streams that have no regulating structures, such as dams, dykes, or other channel modifications.

The method developed by Tennant in 1976 was based on ten years of essentially biological measurements and observations for a selected species, and the discovery of relationships between the physical parameters of the channel (width, depth and velocity) and habitat availability. The method divides the year into two periods (wet year and dry year), allocating to each one a percentage of mean annual flow to obtain the quality of the determined river habitat. Thus the relationship between flow levels and habitat characteristics evaluated is recognized; in addition it takes into account the temporal variability in the measurements.

It is based on a study by the U.S. Fish and Wildlife Service, the objective of which was to find a relationship between flow and habitat availability for aquatic biota. Tennant (lead researcher), divided the year into a dry period and a rainy period, for which he proposed flow expressed as percentages of the mean annual runoff (EMA), relating them to degrees of conservation. Starting from this, it was determined that the habitat began to degrade when the flow was less than 10% of mean annual flow, this associated with an average speed of 0.25 m/s and an average depth of 0.3 m (Tennant, 1976 cited in Bragg et al., 1999).

Several modifications to the method developed by Tennant exist, under certain criteria specific to the region in Mexico. The Montana method has been applied to establish recommended flow rates to evaluate the environmental impact of hydraulic works. In the same manner, modifications to the method have been made for tropical zones, where quarterly annual climatological variation is considered, in an attempt to reproduce flow variations throughout the year (Grace et al. 1999).

Procedure to follow The general application of hydrological methodologies includes following steps:

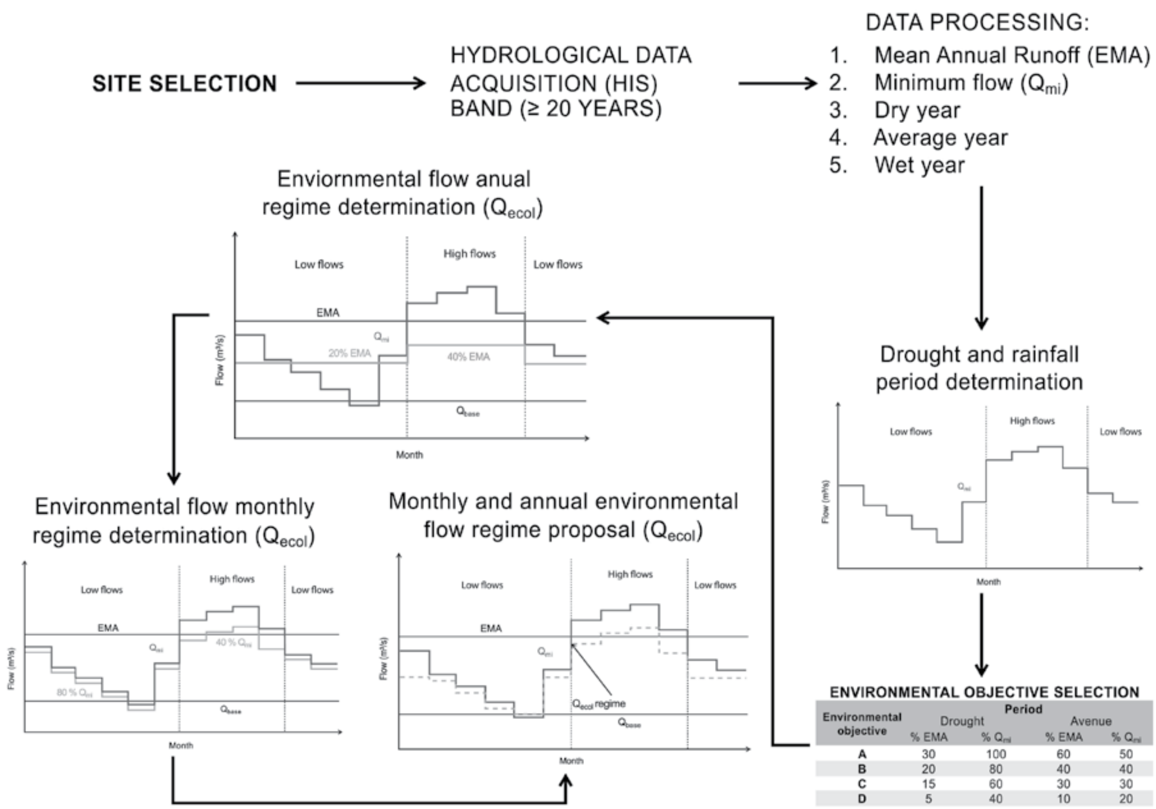
C.1. Selection of study sites.

C.2. Selection of the data series.

C.3. Determination of monthly and yearly ecological flow regime.

C.4. Formulation of proposals for monthly and yearly ecological flow regime.

FIGURE C.1 shows, in sequential order, the steps for determination of the ecological flow regime.



Environmental objective	Period: Drought % EMA	Drought % Q_{mi}	Avenue % EMA	Avenue % Q_{mi}
A	30	100	60	50
B	20	80	40	40
C	15	60	30	30
D	5	40	10	20

FIGURE C.1. Methodological framework for the analysis of ecological flows through the hydrological methodology, based on Tennant 1976 and Garcia et al. 1999.

C.1. Selection of study site.

Based on adequate scale maps, the following should be identified and localized with in the study area: (Figure C.2):

- **a.** The contributions by tributaries and points of decrease of flows.
- **b.** The points where more pronounced changes can be produced by varying the flow
- **c.** Those specific and critical points, either because they are necessary for a particular environmental objective, or because they are scarce or unique to the segment studied.

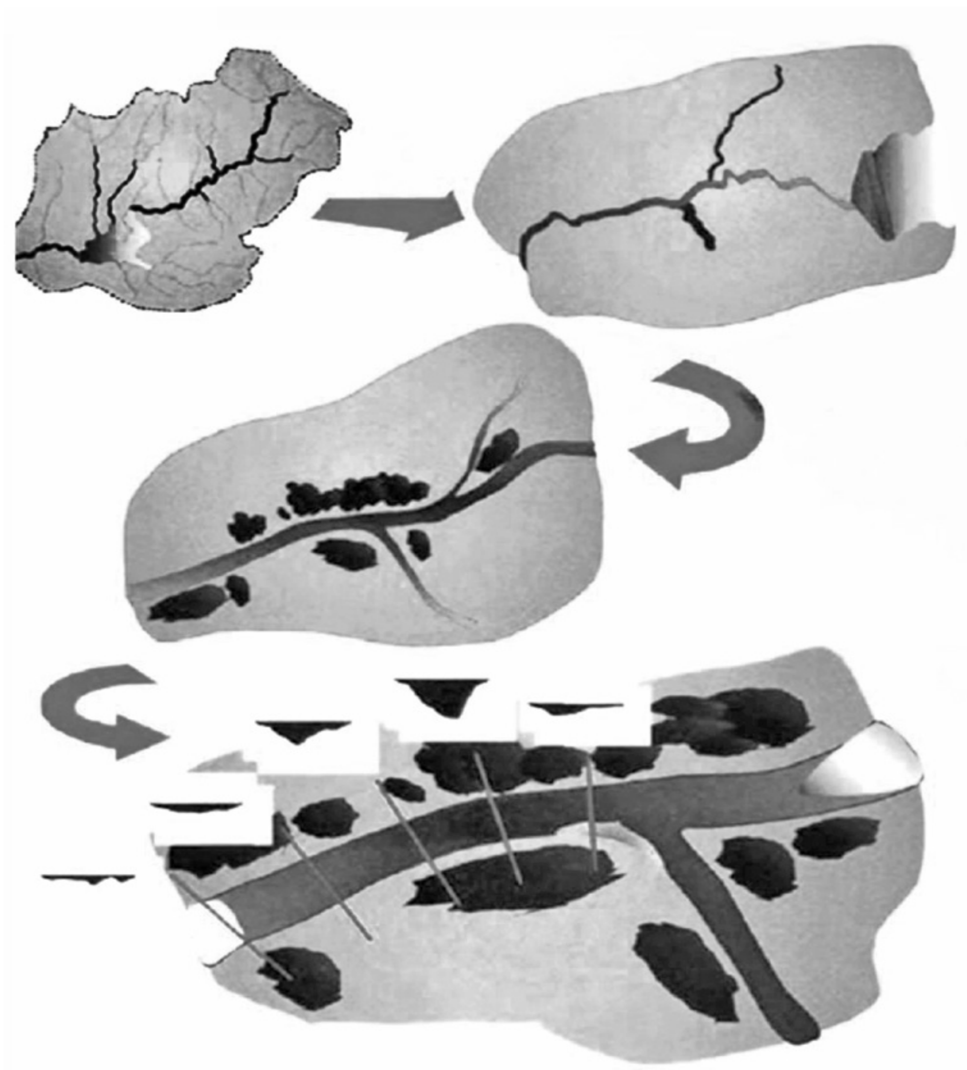


FIGURE C.2. Schematic illustration of the study site selection within the basin.

C.2. Selection of the data series.

The original or natural mean daily flow for the basin should be obtained, from at least 20 years of continuous hydrometric information, based on the information recorded in hydrometric stations. It is worth noting, that before starting the calculations necessary to determine the ecological flow regime, a hydrograph must be constructed for each of the years, identifying possible errors in the data which may bias the results of calculations.

C.3. Determination of monthly and yearly ecological flow.

- Determination of dry, average and wet years.

With erroneous data removed, the maximum value for each month is identified from mean monthly flows (C_{mi}) and the year with highest volume of runoff is determined (wet year), in the same manner, for a dry year the minimum monthly values are identified, based on C_{mi} and the year with the least runoff is determined:

$$\textit{January}_{dry} = \textit{Minimum value} (\textit{January}_{year_1}, \textit{January}_{year_2}, \textit{January}_{year_3}, \cdots, \textit{January}_{year_n})$$
$$\textit{February}_{dry} = \textit{Minimum value} (\textit{February}_{year_1}, \textit{February}_{year_2}, \textit{February}_{year_3}, \cdots, \textit{February}_{year_n})$$
$$\vdots$$
$$\textit{November}_{dry} = \textit{Minimum value} (\textit{November}_{year_1}, \textit{November}_{year_2}, \textit{November}_{year_3}, \cdots, \textit{November}_{year_n})$$
$$\textit{December}_{dry} = \textit{Minimum value} (\textit{December}_{year_1}, \textit{December}_{year_2}, \textit{December}_{year_3}, \cdots, \textit{December}_{year_n})$$

$$\textit{January}_{wet} = \textit{Maximum value} (\textit{January}_{year_1}, \textit{January}_{year_2}, \textit{January}_{year_3}, \cdots, \textit{January}_{year_n})$$
$$\textit{February}_{wet} = \textit{Maximum value} (\textit{February}_{year_1}, \textit{February}_{year_2}, \textit{February}_{year_3}, \cdots, \textit{February}_{year_n})$$
$$\vdots$$
$$\textit{November}_{wet} = \textit{Maximum value} (\textit{November}_{year_1}, \textit{November}_{year_2}, \textit{November}_{year_3}, \cdots, \textit{November}_{year_n})$$
$$\textit{December}_{wet} = \textit{Maximum value} (\textit{December}_{year_1}, \textit{December}_{year_2}, \textit{December}_{year_3}, \cdots, \textit{December}_{year_n})$$

For the years considered average, the mean of each of the months is calculated based on the C_{mi} and thus an average year is determined. The base flow should be determined from the analysis of hydrographs, which corresponds to the minimum monthly mean flow and represent the contribution of the aquifer to the stream under study:

$$\textit{January}_{average} = \textit{Average} (\textit{January}_{year_1}, \textit{January}_{year_2}, \textit{January}_{year_3}, \cdots, \textit{January}_{year_n})$$
$$\textit{February}_{average} = \textit{Average} (\textit{February}_{year_1}, \textit{February}_{year_2}, \textit{February}_{year_3}, \cdots, \textit{February}_{year_n})$$
$$\vdots$$
$$\textit{November}_{average} = \textit{Average} (\textit{November}_{year_1}, \textit{November}_{year_2}, \textit{November}_{year_3}, \cdots, \textit{November}_{year_n})$$
$$\textit{December}_{average} = \textit{Average} (\textit{December}_{year_1}, \textit{December}_{year_2}, \textit{December}_{year_3}, \cdots, \textit{December}_{year_n})$$

- Determination of the periods of low flows and high flows.

For the determination of periods of low and high flows within dry years, average years and wet years, all values of monthly mean flow (C_{mi}) that fall above the value of the Mean Annual Runoff (EMA), are considered flood periods (Figure C.3).

The amount of <u>at least 20 years</u> was chosen because it is considered a representative lapse of time which takes into account the modifications to habitat which communities of the river ecosystem develop. However, this period time is considered <u>the minimum desirable</u>, so that in those cases where it is not possible to have a series with this period of time, a shorter time period may be used, as long as this is representative of all the years under different hydrological conditions (very dry, dry, average and wet years).

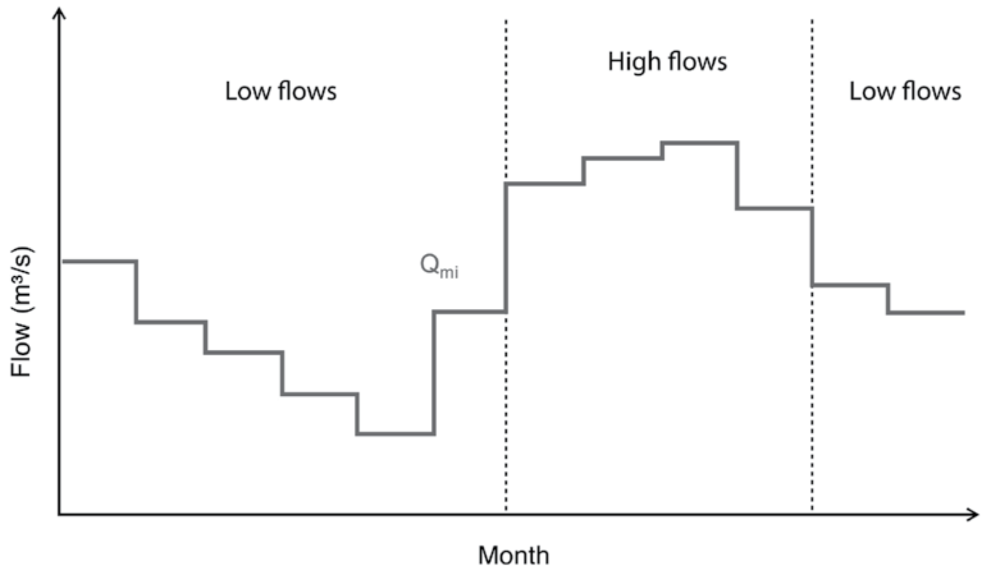


FIGURE C.3. Determination of periods of low and high flows

C.4. Formulation of proposals for monthly and annual ecological flow regime for a typical year and an associated environmental objective.

The monthly ecological flow regime is determined starting with the percentages proposed for the determination of monthly flow rate % Q_{mi} for each period within the year, according to TABLE C.1 for a selected environmental objective.

The annual ecological flow regime is determined from the selection of a typical year (dry, average or wet).

After choosing the type of year, the percentages for the period of drought and rain respectively, are determined, according to the values proposed in TABLE C.1 of the percent of Mean Annual Runoff (EMA).

TABLE C.1. Recommendations of percentage flows with related environmental objectives (Tennant, 1976), as modified by Garcia et al.1999 and proposed by CONAGUA, 2011.

Environmental objective	Period			
	Low flows		High flows	
	%EMA	%Qmi	%EMA	%Qmi
A	30	100	60	50
B	20	80	40	40
C	15	60	30	30
D	5	40	10	20

For a hypothetical environmental objective B, the determination of the monthly and yearly ecological flow regime in a given year is constructed follows:

Based on the average year and the environmental objective B, which was selected hypothetically, we proceed to construct the hydrograph of the ecological flow regime with the parameters listed in Table C.1, where for the dry period, 20% of the Mean Annual Runoff (EMA) is noted (Figure C.4), and 80% of the mean monthly flow for each of the months (Q_{mi}) is noted, (FIGURE C.5); and for the period of high flows, 40% of the Mean Annual Runoff (EMA), (FIGURE C.4) and 40% of the mean monthly flow (Q_{mi}), (FIGURE C.5) is shown.

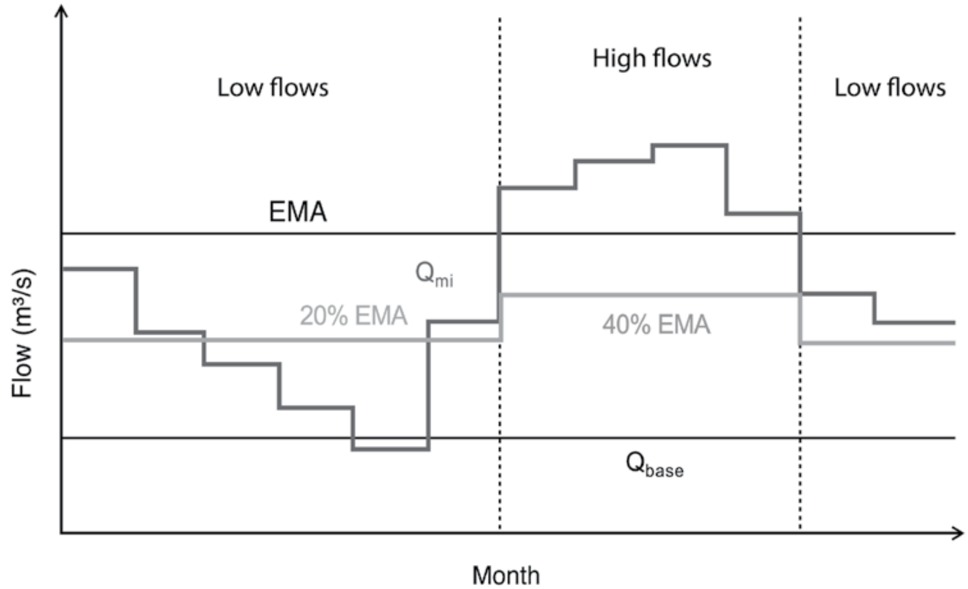


FIGURE C.4. Determination of % Mean Annual Runoff (EMA) for environmental objective B, considering base flow.

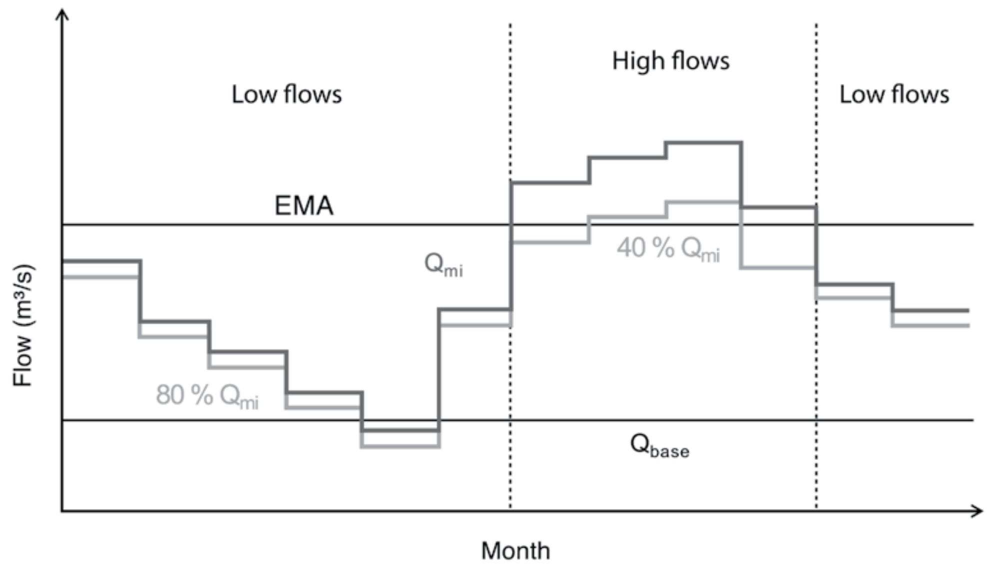


FIGURE C.5. Determination of % Qmi for an environmental objective B, considering base flow.

After establishing the periods of low and high flows, in the dry period between 20% of EMA and 80% of Q_{mi} is chosen, and for the high flows period, between 40% of Mean Annual Runoff (EMA) and 40% of Q_{mi} is chosen, as shown in Figure C.6,. It is worth mentioning that for both periods (rainy and dry) the ecological flow value should never be greater than the mean monthly flow (C_{mi}) or less than the base flow (Q_{base}).

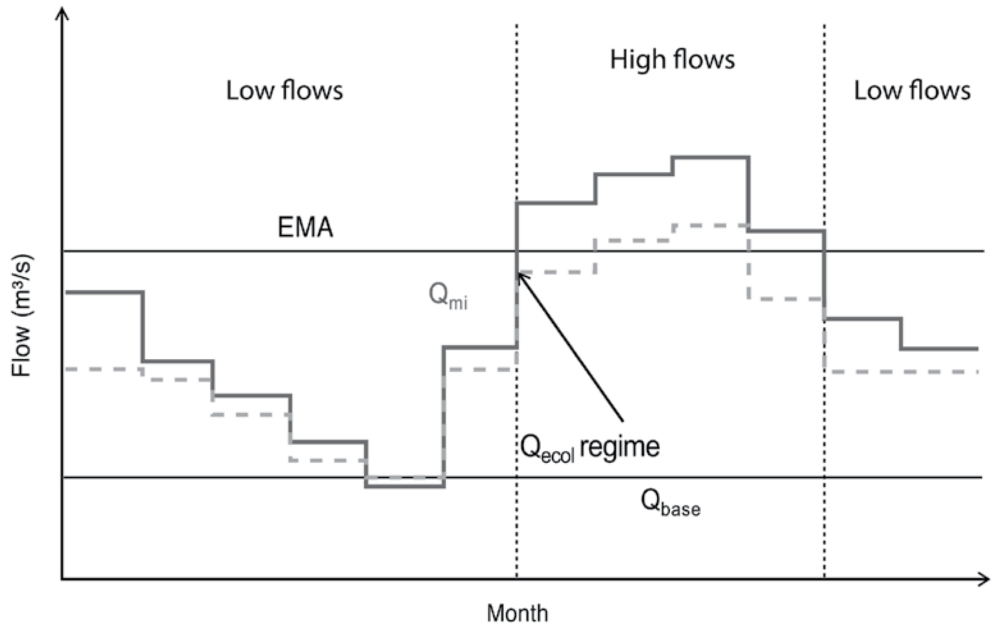


FIGURE C.6. Proposed Q_{ecol} in terms of Q_{mi} and % Mean Annual Runoff (EMA) for Hypothetical environmental objective B, considering base flow as the lower limit.

NORMATIVE APPENDIX D

HYDROLOGICAL METHODOLOGY TO DETERMINE THE ECOLOGICAL FLOW REGIME IN NATIONAL STREAMS OR BODIES OF WATER AT HYDROLOGICAL BASIN LEVEL. PROPOSED METHODOLOGICAL APPROACH FOR THE WWF-GONZALO RÍO ARRONTE FOUNDATION I.A.P. ALLIANCE.

Application D.1. Utilization of reference values

In those national streams or bodies of water at the hydrological basin level where the intention is to conserve the natural hydrological regime in order to reserve a volume of water for environmental use or for ecological conservation under the National Water Act.

Elements of ecological flows to be determined

- Annual regime of flows for environmental purposes;
- Annual volume of water to be reserved for environmental purposes.

Note: In the case where there is no historical hydrometric information on a daily and/or monthly scale, and the only information available is on an annual scale, only the annual volume of water to reserve for environmental purposes may be determined.

Required information.

The following information is required:

- Hydrological information. A series in natural regime (where there are no significant changes from man-made effects in the terms of NORMATIVE APPENDIX B) with at least 20 complete years of information is required. For smaller sizes of series, they must be equally analyzed to include the presence of wet, average, dry and very dry years. Also, in cases where the series is greater than 20 years, and in the terms of the NORMATIVE APPENDIX B, the hydrological regime is not significantly altered, the complete series may be used.

Procedure to be followed

The procedure to determine the volume of reserves with environmental purpose in a national stream or body of water at the hydrological basin level is:

D.1. Identify the environmental objective for the basin according to what is set out in NORMATIVE APPENDIX A.

D.2. According to the environmental objective and the nature of the stream (permanent or intermittent), consider the interval of percentages of Mean Annual Runoff (EMA) as reference values for ecological flow as shown in TABLE D.1.

TABLE D.1. Reference values to assign an ecological flow volume according to environmental objectives.

Environmental Objective	State of Conservation	Ecological Flow (%EMA)	
		Perennial Streams	Temporal Streams
A	Very Good	≥40	≥20
B	Good	25-39	15-19
C	Moderate	15-24	10-14
D	Deficient	5-14	5-9

D.3. Allocate a percentage of reserves within the range defined by the environmental objective. The adjustment within the range defined by the environmental objective must be high to low (e.g. environmental objective "B" 40, 39, 38, ..., 25) considering at all times the interest of conservation of the basins (with special observance on Protected Areas and the conservation of endangered species), potential conflicts with the other uses of water or the particular conditions of the mass water (such as pollution or morphological alteration).

D.4. For the particular case of perennial streams, base flow shall be determined as the minimum monthly flow and will form part of the ecological flow. The percentage of natural discharge of the aquifer towards the surface stream, which will be part of the ecological flow, must be at least that which is shown in TABLE D.1, according to the interval of the assigned environmental objective, and further using the following rule or criterion: If in dry season the percentage of the mean monthly flow according to the environmental objective is below base flow, then the ecological flow to be assigned for that month shall be at least equal to the base flow. However, except in situations where specialized studies identify a specific base flow for the analyzed ecosystem, this may be the assigned flow. The natural aquifer discharge associated with wetlands, lakes, ponds, swamps, springs or other bodies of water or ecosystems is determined directly by identified base flow and assigned environmental objective.

Application D.2 Detailed hydrological approach

In those segments where there are hydraulic works in existence (e.g. large dams or diverters) or water intakes (e.g. pumping of wells) significantly affecting the hydrological regime of the national streams or bodies of water (in terms of NORMATIVE APPENDIX B), and consequently the associated aquatic ecosystems. The aim is to preserve, to recover or reconstruct the existing hydrologic regime based on the natural hydrological regime. In all of these cases, hydrologically detailed determination of an ecological flow regime will be necessary.

The elements of ecological flows to be determined

The following are elements and aspects of the regime of ecological flows to be determined:

1. Annual regime for ordinary seasonal flows for wet, average, dry and very dry conditions.

2. Flood regime, considering at least three categories of floods (intra-annual, low magnitude inter-annual, and medium magnitude inter-annual) with corresponding attributes of magnitude, duration, frequency, time of occurrence and rate of change.

3. Annual volume of reserves for environmental purposes.

Required information

The following information is required:

Hydrological information. A series in a natural regime is required (where there are no significant man-made changes, in terms of NORMATIVE APPENDIX B), on a daily scale and with at least 20 full years of information. For smaller sizes of series, they must be equally be analyzed for inclusion of the presence of wet, average, dry and very dry years. Also, in cases where the series is greater than 20 years, and in the terms of the NORMATIVE APPENDIX B, the hydrological regime is not found to be significantly altered, the complete series may be used.

Procedure to be followed

The procedure for determination of the regime of ecological flows and subsequent annual reserve volume in a stream or national body of water for environmental purposes at hydrological basin is as follows:

D.1. Identify places where the study of ecological flows will be carried out. For this, consider the criteria established by the National Water Commission.

D.2. Identify the environmental objective for each study site, according to NORMATIVE APPENDIX A.

D.3. Determine the regime of ordinary seasonal ecological flows for each hydrologic condition (wet, average, dry and very dry) according to the procedure detailed below:

a. Add the available hydrological information for mean monthly flows;

b. Organize monthly flows in calendar years;

c. Based on the ordered series, for each month of the year, calculate the 75, 25, 10 and 0 percentiles.

d. Associate the type of regime of ordinary seasonal flow (wet, average, dry and very dry) to percentiles shown in the following TABLE D.2.

Table D.2. Criteria for choosing the ordinary seasonal flow regime for years with different hydrological conditions.

Hydrological Conditions	Percentiles
Regime of ordinary seasonal flows for wet years	75
Regime of ordinary seasonal flows for average years	25
Regime of ordinary seasonal flows for dry years	10
Regime of ordinary seasonal flows for very dry years	0

e. According to the class of environmental objective defined in segment D.2. of this Appendix, consider the following seasonal occurrence frequencies of TABLE D.3. for implementation of ordinary seasonal flow regime:

TABLA D.3. Criteria for the integration of ordinary flows starting from the frequencies of occurrence of differing hydrological conditions for the environmental objectives.

	Frequency of occurance of ordinay seasonal flow regimes			
Environmental objective	Wet	Average	Dry	Very Dry
A	0.1	0.4	0.3	0.2
B	0.0	0.2	0.4	0.4
C	0.0	0.0	0.4	0.6
D	0.0	0.0	0.0	1.0

D.4. Determine the flood regime according to the following procedure:

a. Categorization and description of the flood regime.

Identify types of floods necessary to maintain ecosystems in the long-term, and describe their basic characteristics (magnitude, frequency, duration, time of occurrence and rate of change).

i. Based on the available hydrological series, calculate, and categorize types of floods with a return period of 1, 1.5 and 5 years, depending on the methodologies established by the National Water Commission or other equivalent hydrological analysis. These categories will serve to identify Class I, II and III floods respectively;

ii. Characterize the patterns of duration, time of occurrence and exchange rate of the three types of floods.

b. Adoption of a flood regime.

Identify the type and characteristics of the floods that will be part of the overall proposed ecological flows (Table D.4).

i. Select a duration, time of occurrence and representative rate of exchange for each type of flood;

ii. Adjust the proposed flood regime to the environmental objective based on the frequency of occurrence of the floods. For a time horizon of 10 years, the following are proposed:

Table D.4. Criteria to integrate flood types by their frequency of occurrence according to environmental objectives.

		Flood Regime	
Environmental objective	Category 3	Category 2	Category 1
A	2	6	10
B	2	3	5
C	1	2	3
D	1	1	2

D.5. Determine the final reserve volume or ecological flow to integrate into availability studies, based on regime obtained by this approach. The calculation must be performed as follows:

For different ordinary seasonal flow regimes (wet, average, dry and very dry), consider the annual volume of each multiplied by their corresponding occurrence frequencies defined in paragraph D.3.). This volume is determined by the following expression:

$$Vt_{Coe} = (f_{CoeH} \times V_{CoeH}) + (f_{CoeM} \times V_{CoeM}) + (f_{CoeS} \times V_{CoeS}) + (f_{CoeMS} \times V_{CoeMS})$$

Where:

Vt_{Coe} is the total volume of the ordinary seasonal flow;

f_{Coe} is the frequency of occurrence of a regime "i"; and

V_{Coe} is the volume of ordinary seasonal flow regime "i", "i" being wet, average, dry and very dry conditions.

- For the flood regime, consider the annual volume each type of flood multiplied by their corresponding occurrence frequencies defined in subparagraph D4. b) ii). This volume is determined by the following expression:

$$Vt_{Ra} = (f_{aI} \times d_{aI} \times V_{aI}) + (f_{aII} \times d_{aII} \times V_{aII}) + (f_{aIII} \times d_{aIII} \times V_{aIII})$$

Where:

Vt_{Ra} is the total volume of the flood regime;

f_{aI} is the frequency of occurrence of a flood "i";

d_{aI} is the duration of a flood "i", and

V_{aI} is the volume of a flood "i", where "i" is flood types 1, 2 and 3.

- The final volume of reserve or ecological flow to be integrated into the availability studies, will be given by the sum of the ordinary seasonal flow regimes and corresponding floods;
- The results of each segment of study will be raised to the basin or sub-basin level, following the rules set by the National Water Commission.

NORMATIVE APPENDIX E

HYDROBIOLOGICAL METHODOLOGY TO DETERMINE THE REGIME OF ECOLOGICAL FLOW IN NATIONAL STREAMS OR BODIES OF WATER AT HYDROLOGICAL BASIN LEVEL.

Background

The IFIM methodology was developed by the U.S. Fish and Wildlife Service in collaboration with a multidisciplinary team, based on the knowledge and basic descriptions of the interrelationships that exist between the amount of water circulating and the amount of habitat that is generated on a stretch of riverbed.

The incremental methodology (Instream Flow Incremental Methodology: IFIM) is based on a variety of approaches that have been developed for evaluation of the effect of variation of flow in channels (Bovee, 1982). Within this general methodology, the simulation model is specifically designed to calculate the amount of habitat available for a given species depending on the circulating flow.

Throughout the years, various habitat simulation models (PHABSIM, RHABSIM, RYHABSIM) have been developed which have been widely used and contrasted at the international level. All these models are based on the same fundamentals, which can be summarized in the following issues:

1. Each species has a range of preferences of habitat conditions or, likewise, has determined tolerances to certain habitat parameters (stream velocity, depth or substrate type, among others.).

2. The boundaries of these preferences can be determined for each species through a detailed study thereof.

3. Based on the characteristics of the channel, the amount of habitat for these species can be determined as a function of flow.

The habitat simulation model (either PHABSIM, RHABSIM, RYHABSIM, or equivalent) consists of two main components. The hydraulic model predicts the depth and the water velocity in a transverse section of the channel from real data taken in the channel for a given flow rate. The adjustment of the model allows prediction of the behavior with other flows without the need to wait for the real occurrence. For its part, the habitat model weighs each cell in which the transverse section is divided using indices that assign a value between 0 and 1 for each habitat parameter considered (depth, velocity, substrate, and coverage), indicating how adequate each is for the species concerned. The habitat model computes these values for different flow values, obtaining a usable area index called the Weighted Useable Area (WUA).

FIGURE E.1 synthesizes the different parts of the hydrobiological model.

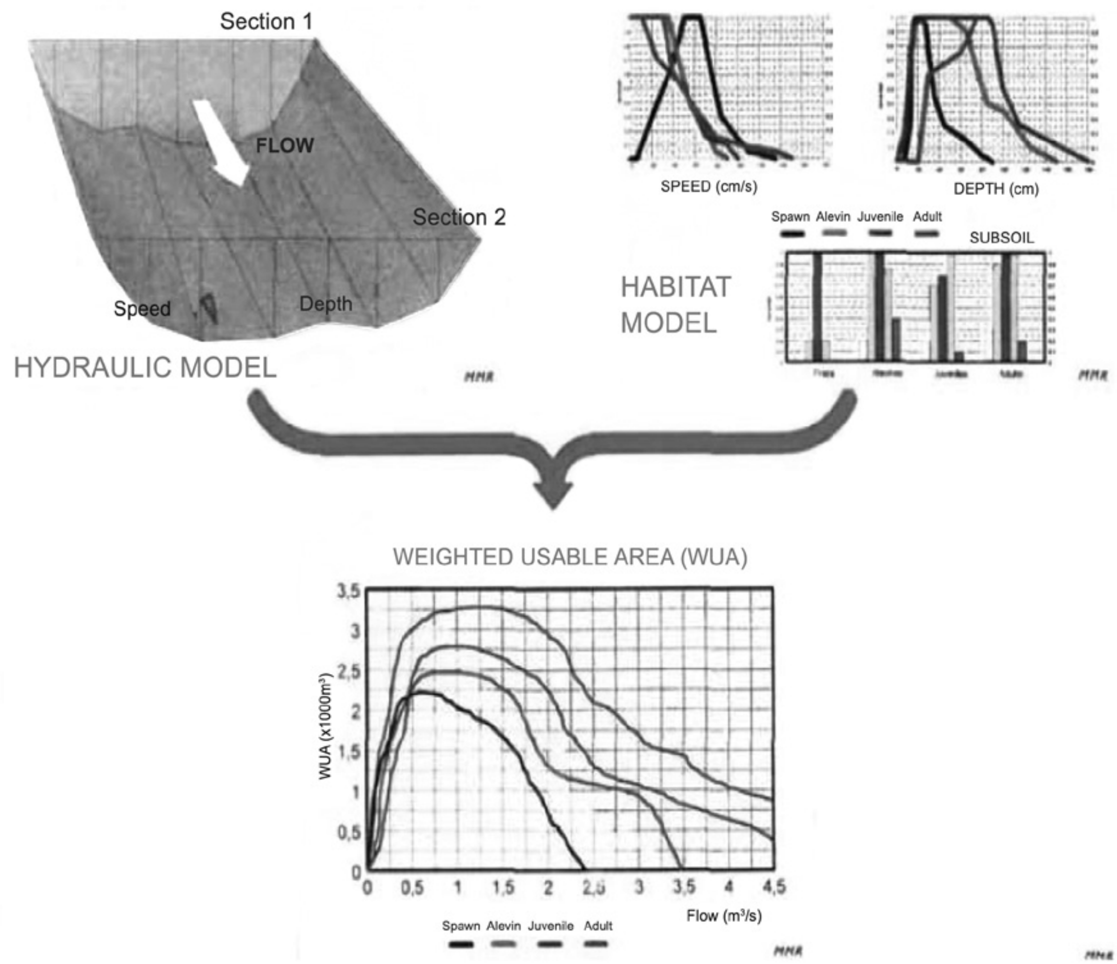


FIGURE E.1. Conceptual model of the methodological procedure to analyze ecological flows using habitat simulation methodology.

Procedure to be followed The application of the hydrobiological methods is comprised of the following key phases (Figure E.2):

E.1. Selection of study sites.

E.2. Selection of representative target species of the study site.

E.3. Generation of microhabitat preference curves as an essential element in generating habitat models.

E.4. The field work destined for the construction and calibration of habitat models.

E.5. Evaluation of the river habitat.

E.6. Formulation of proposals for ecological flows.

The following diagram shows, in sequential form, the work associated with each of these phases.

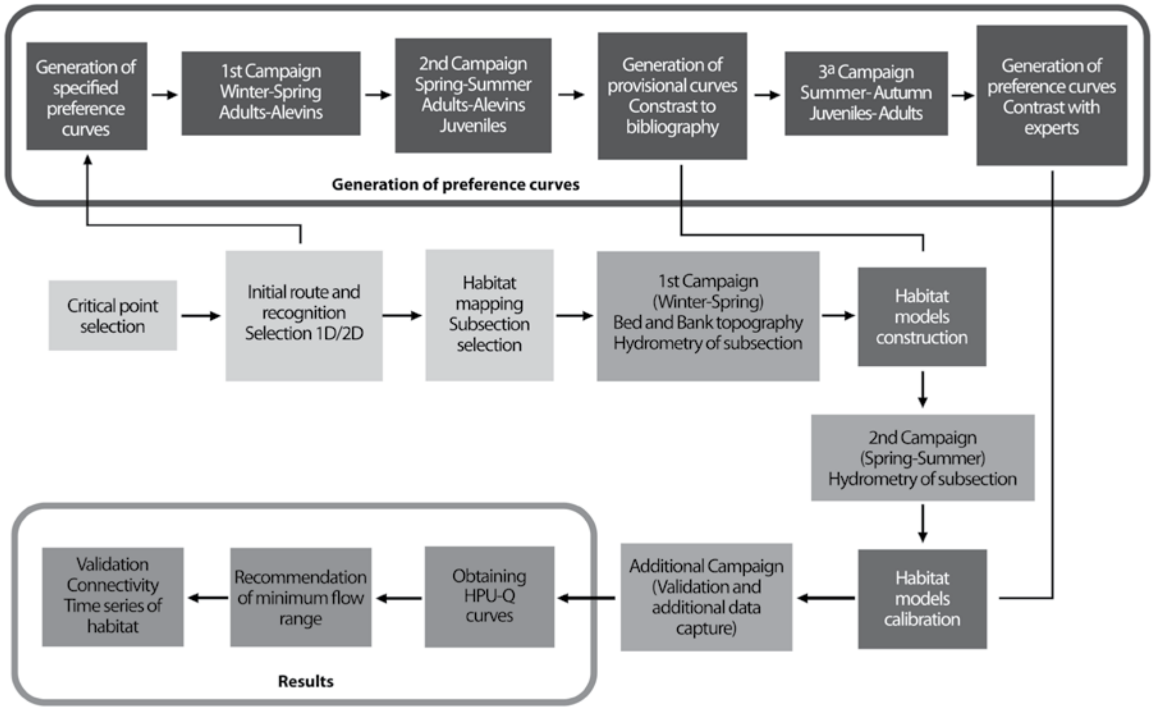


FIGURE E.2. Methodological scheme for the analysis of ecological flows through physical modeling of the habitat.

E.1. Selection of study sites.

These should be identified and located within the study area using adequate scale maps:

1. The contributions by tributaries and points of flow decrease.
2. The point where more pronounced changes can be produced by variation in the flow, or where variations in water quality may be produced.
3. The distribution of species in the segment in question.
4. Those specific and critical points, either because they are necessary for a particular life stage or for a particular species, or because they are scarce or unique in the segment under study.
5. Random distribution of the sampling points of larger segments.

The number and location of sites (Figure E.3) where the simulation of the physical habitat will be carried out should cover, as a minimum, a segment in each of the most representative types, especially in regard to differences in the flow regime. In this selection of sites priority is to be given to bodies of water with higher environmental importance or those who are downstream of large dams or major derivations, which may impose conditions on allocations and resource reserves.

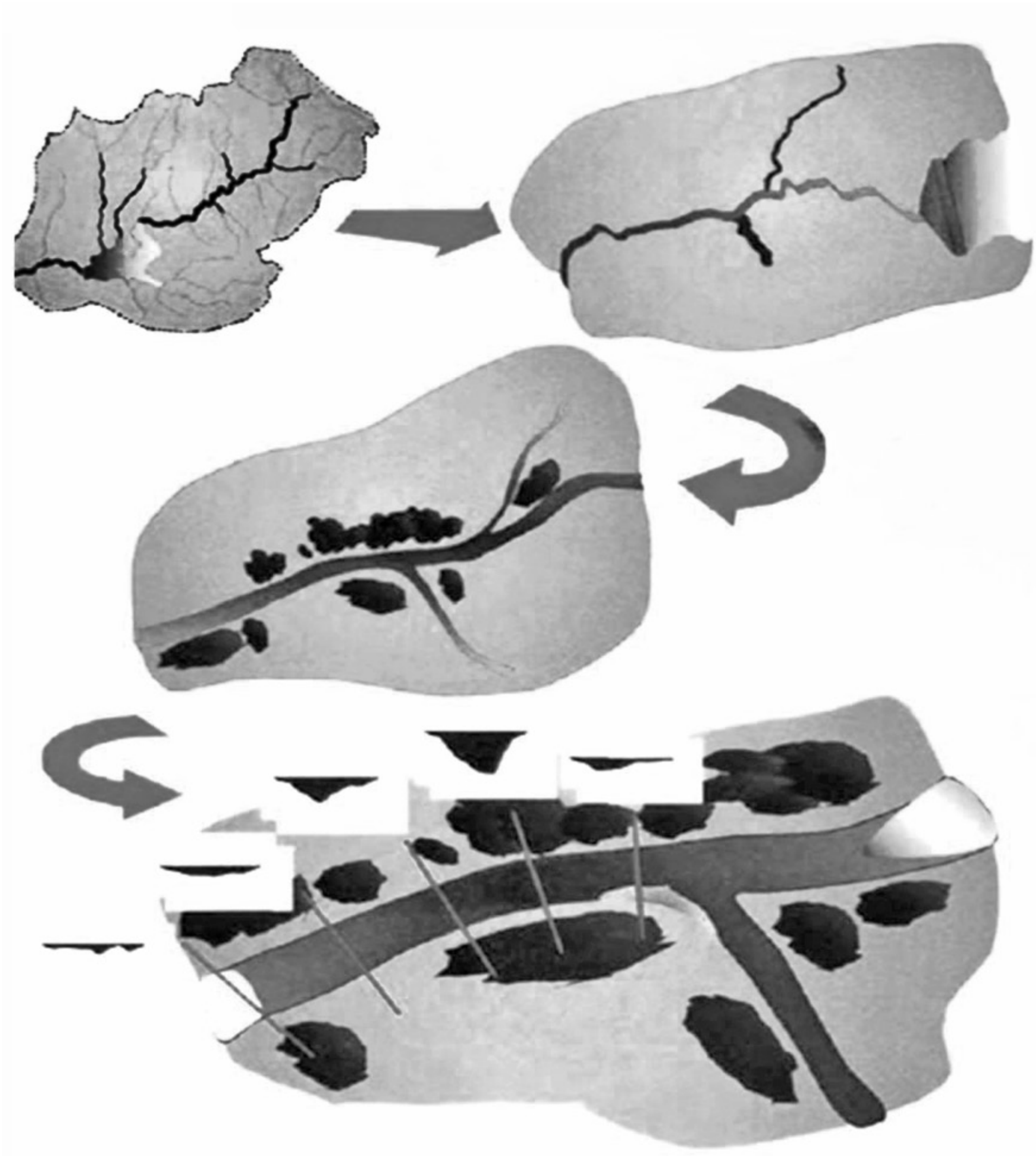


FIGURE E.3. Schematic illustration of study site selection within the basin.

E.2. Selection of target species.

To evaluate the potential habitat in the river as a function of the circulating flows, first the species, whose ecological interest and indicative value allow selection as an ecological objective, must be defined. In this respect, it is noteworthy that, both in national and international experience, the use of fish species as indicator species is more developed. Although there may be local research which facilitate the study of other species related to the river environment (bank vegetation, macro-invertebrates, birds, etc.), it is advisable to use fish species in order to benefit from pre-existing experiences and knowledge. As a first analysis it is recommended that protected, sensitive or vulnerable species be inventoried.

For the selection of the target species that is to be included in the physical habitat analysis, several criteria must be considered:

1. The presence of said aquatic species in the study segment, and their relationship to the quality status of that segment. This means that species considered non-native species to each basin are not used in the study, since from a scientific and legislative viewpoint, they are considered as a degradation factor of the segment, and an indicator of the situation. Besides the species detected in the study segments, historical reference species should also be considered. That is, that certain organisms not present today may be a historical reference for more desirable ecological conditions.

2. In the selection of species, those species sensitive to changes in their habitat, in danger of extinction, vulnerable or of special interest should be given priority.

3. The possibility of having suitable habitat features for that species or the viability of creating them through field work (see next item). The generation of such curves is extensive for fish species, as already mentioned.

Taking into account the characteristics of selected segments, generally one or more fish species, defined as species of interest, is chosen. From this selection of species, it is important to specify the target species, analyzing its highest and lowest flow requirements, and the characteristics of its protective figure. Additionally, a sensitivity analysis should be performed to identify significant differences between the regime obtained by the more restrictive species, and that obtained from the analysis of species of fewer requirements.

After selecting possible target species, it is advisable a to do a simple analysis to summarize the life cycle of each species, and identify during what season it is found and its stage of development. Through this analysis, a deduction may be made regarding the critical periods for each species and stage of the hydraulic year. Said periods determine in which seasons habitat conditions of one species or another should be prioritized, to favor and to try to ensure the survival of all populations over time. Thus, once the simulation of the habitat has been carried out, in each season, only the developmental stages found in their own window of time will be considered, since otherwise decision making could be overly complex. Thus, determination of flow-potential useful habitat curves will be applied to each ecologically significant time period.

This is not about painting a very precise picture, nor one with very short and narrow intervals, since natural variability is seen from one year to another. The intention of the identification of these biological periods through ecological flow regime is that throughout the years, the average conditions are adequate for survival of aquatic communities. Therefore, excessive detail regarding time periods is not needed, the monthly scale being, a priori, the most suitable.

E.3. Development of preference or suitability curves.

Preference features of a microhabitat form a fundamental element to apply to physical habitat simulation. Generically, the microhabitat preference functions are curves or mathematical functions that attempt to describe the suitability of a variable of the microhabitat (to be integrated into a model of the river) for the life of a species, in a stage of development or within a range of size. This response is rated from 0 (minimum or unacceptable values for the life of the species in medium to long term) and 1 (the value of one for a variable) represents the highest suitability for that organism). Regarding the variables used, they may be chosen according to the biology of the species, but must always relate to the conditions of flow. Most commonly, speed, depth, substrate and shelter are used.

Information about microhabitat preference may be obtained in 3 different manners:

1. The selection of different types of curves published in the country, and of common use in the U.S. due to the great variety of studies available; thus the search for scientific references is the primary source of information. For the selection of curves, the conditions of rivers of origin must be taken into account, and compared with the study segment (season of the sample, size used, activity of the organism, mean annual flow, flow regime, elevation, slope, depth, and average speed).

2. Studies done in segments of the study basin, which are the most accurate and reliable, if proper techniques are applied (Bovee et al., 1998), as explained in this chapter.

3. Performing tests of transferability of functions in the same species developed in other rivers, which also requires taking of field data and a subsequent application of a statistical validation test, chosen according to the type of function that we have (univariate curves, logistic presence/absence model). Said tests often give a probability that the use of the microhabitat is selective, according to curves of the river of origin, but a positive result is not entirely comparable to the development of curves in situ. It is generally recommended, wherever possible, to carry out studies in the actual basin.

According to the information used for their development, preference functions of the habitat can be grouped into four classes or categories:

- **Category 1 Curves** (Bovee, 1986) based on the opinion of experts, reaching a final consensus by various methods, for example the Delphi technique (Zuboy, 1981).

- **Category 2 Curves** Curves of use or utilization are based on measurements made at the points occupied by the organisms (e.g. fish in feeding activity). This field sample should be done covering an equal proportion of the microhabitat types available in the river studied (in a practical form, they may be grouped into fast-shallow, fast-deep, slow-deep), using what is called the method of equal effort (Johnson, 1980). By applying this method, the error caused by the effects of habitat availability on selection for organisms is reduced, this error is also reduced by considering several different segments of the same river and by using large sample sizes. It is generally considered that the range of 150-200 pieces of data, a curve can be obtained (for a species, size, activity) that is relatively stable for the sample size, so it is always recommended to have more than 200 independent pieces of data. Currently the method of equal effort is the most recommended for the development of functions of microhabitat preference.

- **Category 3 Curves** These were developed from the so-called selection indices, originally applied in studies of food selection. These functions are based on the Manly, et. al concept of preference (1993), which is the use of a resource (type of specific microhabitat) at a higher proportion than which is found in the environment. Use generates different problems, depending on the size of range and the sample size used, which should be high; hence, their use is not recommend, the use Category 2 curves being more accepted for the equal effort method. This does not mean that Category 3 curves have no validity, only that in some cases, misapplications of the method, as well as certain statistical drawbacks have been observed. Today, a relevant proportion of preference curves that are available and used in different countries, belong to this type and are valid.

- **Category 4 Curves** These encompass conditional curves (Bovee et al., 1998), presence/absence models obtained by nonlinear regression (Rubin 1991, Lamouroux et al., 1999), and other multivariate functions obtained by other statistical methods (see Ahmadi-Nedushan et al., 2006, Schweizer et al. 2007). Conditioned curves are very useful for reflecting biological interactions in the aquatic environment, for example between use of depth and shelter (Bovee, 1998). For certain fish, the suitability or preference of shallow areas is low when there is no haven of overhanging vegetation, or in water of a certain turbidity; however, other selection conditions the selection of shallow areas increases.

E.4. Development of the hydraulic model.

The modeling of the physical habitat requires intensive fieldwork designed to select the proper segment for simulation, characterize its morphology and compile the values of the main hydraulic variables.

E.4.1. Integral recognition and choice of segment for simulation.

Once the sites in the basin that where the hydro-biological method application will take place are selected, it is necessary to identify a segment that contains a good representation of units mesohabitat or morphodynamic units (pools, rapids). For selection of sub-segments, the following phases will be carried out:

i. Identify segment and integral path. Once the segment is selected, a preliminary identification will be done by orthophoto, identifying, as far as possible and if the riparian vegetation in the image does not conceal the water surface, the mesohabitat changes, and barriers, and irregularities that may affect the flow. Through this first identification a preliminary selection of the segment of the body of water where a detailed field survey should be performed to identify present mesohabitats. Subsequently a comprehensive tour of the segment will be done to identify all mesohabitats.

ii. Selecting the modeling segment. Analysis of collected data will permit selection of a length of the stream that has a similar proportion. It is recommended that the selected segment possess a series of hydraulic characteristics to facilitate model calibration. In particular, an attempt should me made so that the sub-segment chosen ends in a pool, so that the hydraulic conditions of the segment may be independent of potential alterations downstream of it. It is also recommended that in the segment there be control sections or transects which allow good quality appraisals. It is advisable to place the beginning of the segment in one of these sections, in which the rating curves of the model may subsequently be calibrated.

iii. Marking the segment. After selecting the segment, it is necessary to mark the transects in all mesohabitat transitions, the initial and final segments and all those considered appropriate to bring together the variability of microhabitat conditions that occur within each mesohabitat. The number of transects depends on the mesohabitats present, their length and the total length of the segment. But as a recommended average, there should not be less than 10 and; to economize resources, it is not recommendable to have more than 30 transects. A reasonable number would be between 15 and 20.

E.4.2. Field campaigns.

Once the sub-segments are selected and the transects are identified, field campaigns must be done. These are designed to carry out the necessary of topography and hydrometry work for the construction and calibration of models.

i. Topography. Using optical or laser level, total station or high precision GPS, detailed topographical description of the riverbed and the banks will be done (Figure E.4). In each transect, a survey will be conducted, to define with precision the transverse profile, including surveying the banks and riverbed area that can appear dry. This survey should allow definition of the profile of the transverse segment (bank-full), so it is advisable to adequately extend data collection to the riverbanks.

ii. Hydrometry and hydraulics. In addition to the topographical work, measurement of velocity and water depth is carried out, relating these to topographical surveys done. The procedure consists of starting from one of the banks and taking depth measurements at preset intervals, in function of the channel width. Taking measurements at intervals greater than 1/10 of the channel width in the transect is not recommended. However, these ranges may vary in order to better characterize the possible irregularities of the streambed or stream. Besides these basic variables, the slope and longitude of the segment, as well as the roughness coefficient or friction coefficients of the segment and the roughness coefficients of each of the cells in which the segment is subdivided should be determined.

iii. Other data to be gathered in the field. It is advisable to gather the following additional field data in addition to those already mentioned:

- Develop a scheme that reflects flow irregularities, the substrate and the banks of each transect;
- Identify the shaded areas and apparent shelters observed;
- Obtain photos downstream and upstream of each transect;
- Registry of substrate percentages at each point of measurement.

E.5. Evaluation of the river habitat.

After evaluating all the elements of the segment under study (physical structure of the channel, hydraulic parameters governing runoff and availability of shelter), we proceed to study the effects caused by changes in flow. The process of hydraulic simulation permits knowing, for each circulating flow , the depths and average speeds in each cell of the transect, the real width of the channel, the surface of the segment, its depth and average velocity, its wetted perimeter and hydraulic radius.

Once a species or target species is selected, and their habitat preferences known, a calculation of the changes that flow variation introduces into the habitability of the segment. Preference features reflect the predilection or tolerance of a species to the different values a particular habitat parameter can present. Preference may be evaluated according to the probability of finding an organism certain conditions, assigning a value of 0 to 1. Providing for these functions, the habitability for a determined flow can be quantified depending on the suitability of the conditions that this generates. The parameter that evaluates Potential Useful Habitat (HPU) is an indicator of the usable area for the target species, minus those weak points that may occur across the width of the segment.

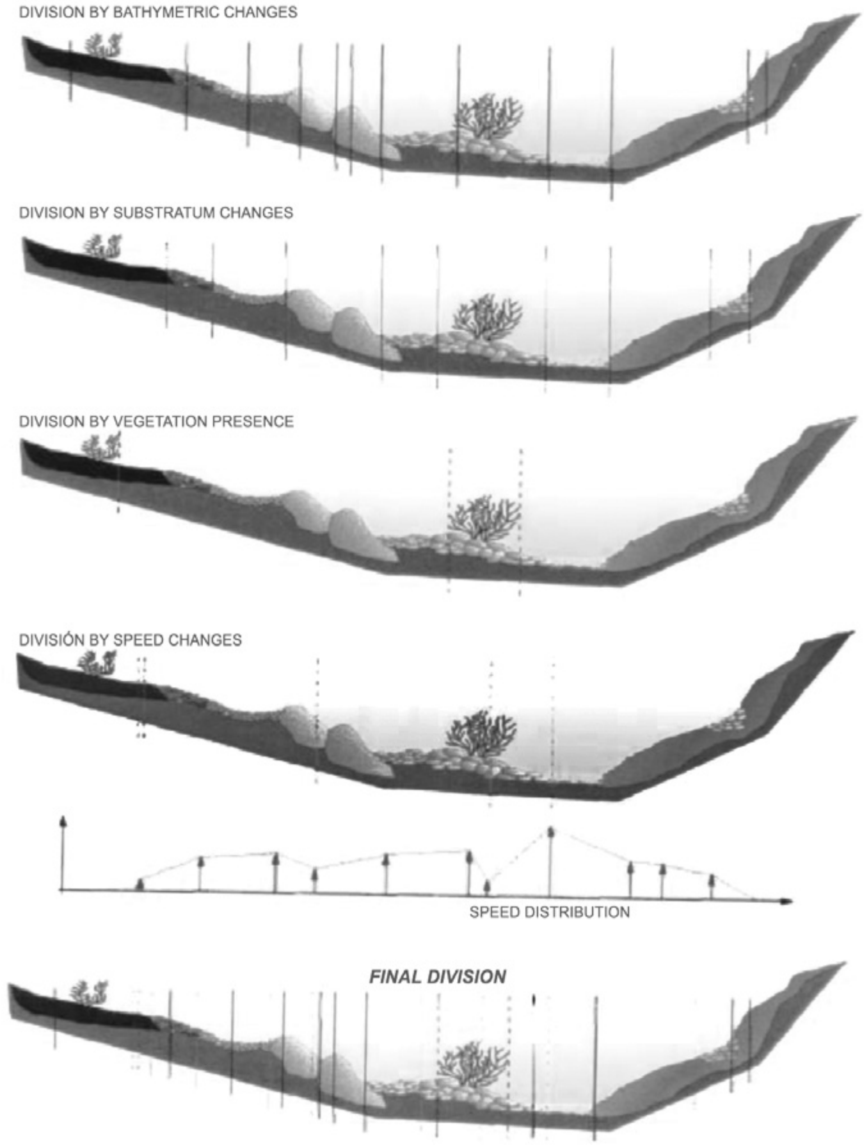


FIGURA E.4. Location of the points to be taken in the peculiarities of the riverbed; the width of the cells are modified to obtain higher precision in the determination of their profile.

Once the simulation has been done, obtaining HPU/flow curves is immediate: through hydraulic simulation, circulating flows are obtained and habitat simulation delivers corresponding HPU values, thus obtaining a series of pairs of HPU/flow values for each transect.

E.6. Formulation of proposals for environmental flows.

On the basis of variations of habitability in relation to the flow, different ecological flows may be proposed, adhering to strictly biological criteria or combined with hydrological criteria. The most frequent options are:

E.6.1. Criteria for formulating proposals for minimum flows.

1. Optimum flow potential. From observation of the HPU/flow curves, a flow called optimal potential immediately arises, which is the flow corresponding to the maximum reached by these curves. This flow produces a potential maximum of habitat in the segment

or section concerned. A greater quantity of water will not mean more quantity of habitat and, in some cases, will be a decline in habitability. This optimum potential may require a large amount of water, which may not exist, even naturally, in a continuously manner, except in rare exceptions.

2. Optimum flow. The HPU/flow curves have a point of inflection, which mark a significant change in behavior in the channel. For this flow, habitat benefits are maximum with the minimum flow possible. Various authors recommend this criterion. The series of optimal flows corresponding to each vital stage, translated to each season of the year in which the segment of the river studied is used by one stage or another, can provide an optimum regime of ecological flows. Thus, the spawning season would be marked by the optimal flow for spawning of the target species; subsequently, and with fingerlings present in the channel, the optimum flow is defined for this stage; an optimal flow, which advances their development is then determined for juveniles, and in any case, effects of these flows are on adults are confirmed..

3. Minimum flows. The optimum flows previously presented are flows which exclusively take into consideration the needs of aquatic species. In cases where there is strong pressure on water resources a decreased of ecological flows should be studied with respect to the biological optimums. For the determination of these reduced ecological flows, existing knowledge regarding the population of the target species should be used (its natural history and dynamics) together with the habitat assessment performed.

E.6.2. Criteria for determining the ecological flow regime.

To determine an annual regime of ecological flows, the phenology of the species under consideration should be taken into account. The most relevant biological processes are:

1. Pre-breeding migration: environmental flows should guarantee the possibility of passage of the species in those critical points present in the segment. These flows must maintain sufficient depth and adequate velocities. The preference functions of the species in question will indicate the optimal or at least, tolerable, magnitudes for such parameters.

2. Spawning season: It is advisable to determine an adequate flow for spawning season, according to the previously analyzed. During this stage, the chances of reproduction should be maximized. However, the geomorphology of the area must be considered, so that the requirements of the flow do not impose spawning areas of difficult access and low use, commanded by very high circulating flows. Likewise, considering the phenology of the area, the possibility must be checked that a few months after spawning some areas may become dry and organisms will be lost.

3. Incubation and hatching: It is clear that during the period of incubation flows must be equal or less than those of spawning season, so that there are no dry areas where the embryos exist. Later, as the hatchings are happen, the flow magnitude may be reduced (as the fry will be more mobile), reaching appropriate values, appropriate to life stage and the time of year concerned.

4. Dry season: In addition to paying attention to the phenology of the area and natural flow distribution, adult needs should be considered, which in general, may be the most demanding stage at this time of year. However, it must be taken into account that fish accumulate in the areas of the segment most favorable for subsistence, and that may a temporary stoppage of passage maybe possible in those critical points.

NORMATIVE APPENDIX F

HOLISTIC METHODOLOGY TO DETERMINE OF THE ECOLOGICAL FLOW REGIME IN STREAMS OR NATIONAL BODIES OF WATER AT THE HYDROLGICAL BASIN LEVEL, BASED ON KING et al. (2000).

The generation of proposals for ecological flow determination through a holistic approach, arises from the experience gained by the WWF-Fundación Gonzalo Río Arronte, I.A.P. Alliance, specific to an adaptation to the Mexican context of the Building Block Methodology (BBM). These proposals should be generated based on the specific characteristics of the areas studied. In particular, the ecological significance of the different components of the hydrological regime, and their relationship with the ecological importance and impact on water use should be identified. Analyses should allow evaluation of conservation or presumed risk scenarios, from different alternatives of water resource management, for different conservation objectives.

Determining the ecological flow regime by using holistic methodologies is recommended for cases where detailed proposals for ecological flow are required, given the complexity, difficulty or social or environmental conflict caused by:

- Potential conflicts between ecological flows and other uses of water, both in quantity and seasonality;

- Areas of priority interest for conservation (ANP, Ramsar sites), CONABIO priority regions, sites of importance for marine and terrestrial biodiversity where ecological flow results predictably cause an impact thereon;

- In the case of ecosystems which because of their functional characteristics the determination of ecological flow by hydrological, hydraulic or hydrobiological methods (lakes, ponds, wetlands and estuaries) is not adequately addressed;

- Feasibility studies for development of projects;

- Reference sites in the hydrological basins where specific monitoring programs or are implemented, or which serve to develop the knowledge of the practice of ecological flows.

F.1. Preliminary activities.

Site information updates should be integrated through participation of a multidisciplinary group of experts covering the following areas knowledge: hydrology, hydraulics, geomorphology, water quality, hydrogeology, vegetation, fish, aquatic macroinvertebrates and socioeconomic aspects.

F.2. Units of study of ecological flow.

The hydrological basin will be considered as the primary unit of analysis encompassing the study or evaluation of ecological flow in accordance with the management units defined by the availability study NOM-011-CONAGUA-2000.

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[2] For more detail on this methodology, refer to JM King, RE Tharme and M.S. of Villeers (editors). 2000. Environmental Flow Assessments for Rivers: Manual for the Building Block Methodology. Water Research Commission Report No.: TT 131/00. Freshwater Research Unit, University of Cape Town, South Africa.

The Ecological Flow Study Unit (UECE) consists of a scale of analysis in the territory of the basin, which defines the unit for evaluation, management and administration of ecological flow. It refers to bodies of water (rivers, lakes, ponds or other wetlands), or parts of them, in the same hydrological basin, which present the same hydrological regime, with the same ascribed environmental objective.

The UECE will be established by basins, sub-basins or specific segments of a stream according to their ecological importance, at water use pressure level in and the presence of anthropic infrastructures that may alter the hydrological regime. The conditions in the previously mentioned features should be similar in each UECE.

The elements and aspects of the scale of analysis to be determined are the following:

1. Hydrological basin: Scale of main analysis where ecological flow proposals from units of study and reference sites are integrated. Represents the water planning unit.

2. Ecological Flow Study Unit (UECE): Superficial bodies of water (rivers, lakes, ponds or other wetlands) or parts of them, in the same hydrological basin, presenting the same hydrological regime and to which the same environmental objective may be assigned. These represent subunits of water management within a hydrological basin;

3. Reference Sites: segments or sections in the body of water in the UECE where detailed analyzes or monitoring ecological flow are done. These represent the finest subunit of study. The results are incorporated into the corresponding UECE, and subsequently into the hydrological basin. Their location should be assigned according to the following criteria:

- Areas of high ecological importance, particularly those under pressure;
- Presence of infrastructure that affect the hydrological regime;
- Representative zones of the availability studies.
- Knowledge of the area by experts, and availability of hydrological, biological, or any other kind of information, which, in the opinion of the experts, should be considered.

The procedure for determining the scale of the analysis is the following:

1. Identify the management unit of the NOM-011-CNA-2000 availability study or the hydrological basin.

2. Depending on the purpose of the ecological flow study, the assignment of analysis scale is detailed as follows:

a. Water Planning: addressing the study through units of management in availability studies, that is, the hydrological basin;

b. Water management: Identify UECE according to the presence of hydraulic or hydroelectric infrastructure present in the hydrological basin;

c. Advanced water management and detailed assessment of projects: In addition to what is stated in the preceding paragraph, identifying at least one reference site in each UECE of the hydrological basin where more detailed information is required (in situ analysis). These sites should be representative of the UECE according to their ecological importance, pressure for use and the knowledge of the area by a group of experts for the following:

- Resolve conflicts between users;
- Validate and calibrate the results of ecological flow;
- Management Programs for Protected Natural Areas;
- Develop project feasibility;
- Evaluate serious potential impacts to the hydrological basin or an area with exceptional natural value (Natural Protected Areas or Ramsar site) by hydraulic or hydroelectric works.

F.3. Selection of reference sites.

A preliminary assessment must be done to identify reference sites, using aerial photographs, overflights or satellite imagery.

Reference sites are those where a detailed study is conducted, including monitoring in the areas of knowledge to generate detailed information of the site. They must be identified on the basis of the extension of the body of water, its biodiversity and resources available, using the following criteria:

- Easy access.
- High diversity of physical habitat for aquatic and riparian species, for their representativeness of the study units of ecological flow;
- Critical habitat for endemic species or those under any protection status protection;
- Habitat sensitive to the variation of flows;
- Easy development of the hydraulic model;
- Near gauging stations with hydrometric information available;
- Acceptance by most participating specialists;
- Other criteria: major tributaries upstream, the state of conservation characteristics of the area, in relation to relevant projects or with potential as a monitoring site.

Reference sites should have a general dimension of at least five times the federal channel width. For each, the different areas of expertise may select their own area or work site, according to their technical needs, to develop the corresponding studies.

Reference sites should not be located in bends, sandy plains with low diversity or stagnant zones that prevent developing a hydraulic model.

Reference sites may be used to monitor the occurrence of ecological flow and compliance with conservation objectives, based in ecological and water management indicators that are properly identified.

F.4. Discussion workshops for the ecological flow proposal.

From the information, analysis and products generated by each of the disciplines (see F.6), work sessions will be held for the discussion of the present ecological status, ecological importance, and sensitivity, conservation objectives, identification of target species and hydrological scenarios, in order to subsequently integrate the proposed ecological flow for the Ecological Flow Study Unit.

The content and next steps to follow in these discussion sessions are the following:

a. Evaluation of reference conditions of the site. Each of disciplines should present to the group, an outline of the natural conditions of the site with the corresponding parameters (species characteristics, typical water quality values, natural hydrological regime and bank vegetation, etc.). Where the site is currently degraded, these conditions will be extrapolated from nearby hydrological basins with similar and hydrological and ecological characteristics, and which are found in a natural state. These terms of reference may also be obtained through models or through the opinion of experts.

b. Evaluation of ecological importance and sensitivity. According the presence and abundance of different taxa, ecological importance at local, regional, national and international levels is assessed (see 5.2.1.1). To evaluate the ecological importance, the degree of endemicity, scarcity, and diversity of species, among other things, will also be taken into account. The conjunction of habitats and species will allow an assessment of the segment's sensitivity to changing hydrological and ecological conditions.

c. Determination of the existing ecological status and the present state of pressure for water pressure (demand). The description of the reference conditions permits assessment of the existing ecological status of the site relative to its deviation from said natural conditions. The analysis of the pressures on the site (including the extraction and flow regulation, contamination or invasive species) will allow understanding of, if applicable, the causes of site degradation and appropriate measures for recovery or restoration. In this aspect, special attention will be given to hydrologic alteration of the site, taking into consideration the modification of minimum flows, seasonality of the same or flood regime.

d. Identification of target species and dominant processes. In certain cases it will be useful to identify species, which for reasons of their sensitivity to the physical variables of the river (mainly depth, and stream velocity) allow easier evaluation of the different ecological flow scenarios. Attention will also be focused on the characteristic ecological, hydrological or geomorphological processes of the site, such as natural processes of flow cessation (in temporal rivers), landforms features like winding channels or connections with subterranean water.

e. Magnitude of base flow. Identifying the magnitude of the base flow as a natural committed discharge of the associated aquifer is of particular interest; its functionality with respect to the natural hydrological regime and the importance of this on target species and dominant processes.

f. Establishment of conservation goals. In this phase, the highest potential conservation status should be put forth, also taking into account the present conditions that cause degradation (degree of reversibility) and the desires of the stakeholders. The desired condition should be translated in terms of abundance or presence of specific species (fish, macroinvertebrates or other biological groups), the composition and structure of riparian vegetation or water quality characteristics.

g. Formulate the proposed flows from conservation goals. This deals with a stage of integration, where based on the information provided by the areas of knowledge (previously compiled or collected in the field), the relationship between the alteration of each component of the hydrological regime, and if applicable, the ecological response to this alteration, should be identified. The proposal of ecological flows should consider at least one flow regime for dry and average years. To quantify each component of the regime of flows, the starting place will be the natural characteristic flows of the site, specifically considering their natural range of variability. The exercise consists of moving from the average conditions of each season of the year (characterized by flow value corresponding to the 50th percentile) to the most extreme natural conditions (percentile 0). In this process, each of the disciplines will identify, starting from physical variables (depth and velocity of the stream) or other water quality variables, hydrologic intervals with which the proposed objective would not be achieved. These interval values are what define the value of proposed ecological flow. Moreover, in the case of the presence of infrastructure, the conditions of the scheme flood with at least the attributes magnitude, duration, frequency, time of occurrence and rate of change, should be specified.

F.5. Information of integration and final proposal

The analysis, discussion and the results of the determination of ecological flow for the hydrological basin should be documented clearly and accurately. This documentation must allow review, monitoring and periodic evaluation.

The content of the reports shall be as follows:

1. Description of the hydrological basin.
2. Selection and characteristics of Ecological Flow Study Units (UECE).
3. Preliminary determination of ecological flows through a detailed hydrological approach that includes the ordinary seasonal flow regime and flood regime.
4. Identification of UECE to be evaluated by BBM.
5. Evaluation of the detailed analysis of UECE.
    - **a.** Selection of reference sites.
    - **b.** Proposal for ecological flow regimes.
6. Evaluation of details for infrastructure projects.
7. Balance of integration of ecological flow values to availability study of the hydrological basin.
8. Appendices. Data sheets for each reference site analyzed.

F.6. Information, structure, and recommended analyses.

The information which should be generated after gathering existing data and field data, including, but not limited to, the objectives of the analysis, elements to be analyzed, recommended information, and products for the different disciplines involved, is presented in the following:

HYDROLOGY

Objective of the analysis:

- To understand the hydrological functioning of aquatic epicontinental ecosystems with the description of ordinary and extraordinary flow values and evolution tendencies of a stream;
- To assess the changes that have been introduced in a river through water use;
- To understand the relationship between groundwater and surface water in the UECE, particularly in the reference site, in order to identify whether it is a perennial, intermittent or ephemeral stream.

Elements to be analyzed:

The different components of the hydrological regime should be analyzed:

- Minimum Flows and their distribution throughout the year;
- Maximum flows and their distribution throughout the year;
- Flood regimes;
- Exchange rate.

It is recommended that the methodological approach put forth in NORMATIVE APPENDIX D - Application D.2. be used.

Recommended Information:

- Hydrological information expressed in the form of flows or contributions from the hydrometric station network, balance of data from reservoirs or rainfall-runoff models developed for this purpose;

- The hydrological series should be on a daily scale, with a minimum length of more than 20 years. However, this period of time is the desirable minimum, so that in those cases where it is not possible to have a series with this period of time, a lesser time period may be used, if and when this is representative of all the years under different hydrological conditions (very dry, dry, average, and wet);

- The period covered by the series should be representative of hydrological conditions of the area, including wet, average, dry and very dry years, according to the monthly regime given for the 75, 25, 10 and 0 percentiles, respectively;

- Where there is no specific information for a basin, data may be used from an adjacent a basin provided that appropriate hydrological techniques are employed and extrapolations are made with sufficient reliability;

- To complete the analysis, series of the natural regime, present regime, or regime in use (if this is the case) may be used.

Products:

- Description of the natural regime.

    - Minimum flows and their distribution throughout the year. Use the analysis of percentiles over series on a monthly scale, using the percentile range between 5 and 25;

    - Maximum flows and their distribution throughout the year. Use the analysis of percentiles series analysis on monthly scale, using the percentile range between 75-95;

    - Flood regime. Identify the magnitude of the maximum ordinary flood using the criteria defined in the National Water Act. The maximum ordinary flood can also be defined using geomorphological criteria. From this threshold value, analysis on the time natural historical series the duration, frequency, and time of occurrence of those flows that are above the set value;

    - Exchange rate. A maximum rate of change will be established, defined as the maximum difference of flow between two successive values of a hydrological series per unit of time, for both conditions of ascent and descent of the flow.

The annual classified series of exchange rates in both ascent and descent will be calculated. By establishing a percentile of calculation in said series, one can count on an average estimate of the exchange rates. It is recommended that this percentile not exceed 90-70%, both in ascent and descent.

In particular cases it will be necessary to consider another timescale that allows limitation of the exchange rate on a regularly scheduled basis (i.e. hourly).

- Description of the modified hydrological regime and evaluation of the alteration.

    - The same elements of the hydrological regime that were used to characterize the natural regime will be described. That is, minimum and maximum flow rates and their distribution, flood regime, and exchange rate. For this, the same numeric criteria (percentiles type and magnitude of floods), will be used;

    - Comparison of the values obtained in the conditions of the natural regime of reference with conditions of water use. The changes observed between the two conditions (natural and use) represent hydrologic alteration;

    - Deviation is considered significant when the magnitude of annual or monthly parameter deviates significantly from percentile values of 10% to 90% of the series in natural regime.

HYDRAULICS

Objectives of the analysis:

- Hydraulic description of transverse sections of the reference sites. Transverse sections will be selected which limit the hydraulic conditions due to their shallow depth, greater susceptibility to drying and loss of connectivity.

Elements to be analyzed:

- Profiles or raised longitudinal and transverse sections in the field, including their hydraulic characteristics and the circulating flows for these sections.

Recommended Information:

- Topographic surveys of the transverse and longitudinal section of the reference site.

- Hydraulic characteristics such as section, slope, frequency curves, average depth and velocity, as well as any other information that, in the opinion of the expert, is important to analyze.

- Appraisals that should be implemented at the same time as the biological studies.

Products:

- Dimensional hydraulic model which permits for different flow scenarios hydraulic parameters partners (speed and depth).

GEOMORPHOLOGY

Analysis objectives:

- Description of the shape of the channel that results from the relationship erosion-sedimentation from runoff, and the materials and sediments which pass and are deposited by the same;

- Determination of the quality and availability of habitat through hydraulic variables, as well as the proportion, distribution, and size of substrate.

Elements to be analyzed:

- Location, input sources and characteristics of sediments based on geological and soil types susceptible to erosion in the basin;
- Description of the inflow valley to the river channel, channel and stream type;
- Profile longitudinal, transverse and degree of dynamism in the sinuosity of the channel and riparian vegetation;
- Type, size and distribution of the substrate present in the channel.
- Erosion-sedimentation relationship.

Recommended Information:

- Topography, terrain and soil types present in the UECE;
- Longitudinal slope based on topographic map and total length of the channel;
- Steepness of the slopes of inflow to the channel, their width, and the width of the channel with water. Additionally, forms of sediment deposits and vegetation therein;
- Degree of sinuosity of the channel;
- Type and size of substrate present in the channel;
- Aerial photographs or satellite images taken at different times.

Products:

- Identification of areas for sediment contribution, and their type within the hydrological basin;
- Geomorphological classification.
    - Type of inflow valley;
    - Type of riverbed-channel;
    - Type of stream;

- Profiles of the channel.
    - Longitudinal;
    - Transverse.

- Sinuosity index of the riverbed-channel;
- Classification of the gravel substrate size present in the channel.

WATER QUALITY

Analysis objectives:

- Identify potential major direct impacts on physicochemical parameters of the water;
- Identify the relationship between circulating flows, the physicochemical parameters of water and biota present in river;
- Identify the predominant land use in the UECE and its contribution as a source of diffuse pollution contribution;
- Determine the existing state of water quality.

Elements to be analyzed:

- Impact of the set of physicochemical information of the water on biota seasonally at a minimum, throughout the annual cycle, and in particular, an inter annual form for arid zones. If possible, also must analyze historical trends over this impact time;

- Impact of the magnitude, duration, and return periods of low and high flow rates the quality of the water. If possible, historical trends over time of this impact should also be analyzed.

Recommended Information:

- Physicochemical parameters.

    - System variables: pH, water temperature and oxygen dissolved;
    - Non-toxic components: electrical conductivity, total dissolved and suspended solids, and base cations and anions;
    - Nutrients: Total phosphorus, soluble reactive phosphate, total nitrogen, nitrates, ammonia nitrogen and total organic carbon;
    - Toxic components: heavy metals, pesticides, hydrocarbons, and those whose presence is suspected.

Products:

- List of qualitative tolerance intervals of biota to changes in water quality, particularly for preselected sensitive species (biomarkers);

- Presence of waste water, the saturation level of dilution and assimilation capacity and present state of water quality in the UECE.

GEOHYDROLOGY

Analysis objectives:

- Understand the interaction of groundwater with the main stream flow;
- Determine base flow and understand its evolution over time;
- Determine the percentage of contribution of groundwater to the mean annual runoff.

Elements to be analyzed:

- Dynamics of associated aquifer (flow direction, natural discharge, recharge, contributions and extractions);

- Contribution of groundwater to rivers and wetlands as base flow (particularly perennials), and the water supply for biota in drought seasons.

Recommended Information:

- Geology, lithology, topography, stratigraphy and physiography of the UECE;
- Information on piezometric levels in the hydrological basin or UECE;
- Characteristics of the aquifer in the hydrological basin or UECE (storage capacity, recharge potential and volume of water extraction.);
- Groundwater quality.

Products:

- Conceptual model of operation, amount of water contribution and the role of aquifers in the UECE in inter and intra annual manner.

VEGETATION

Analysis objectives:

- Describe the structure, composition and spatial distribution-vertical and temporal-of vegetation in the channel (including riparian zone) by a transverse profile;
- Link and identify the magnitude, duration and return periods of low and high flows that aquatic and riparian vegetation need to provide for their functions and services;
- Retrospective and trend analysis and information from historical presence information (list of species).

Elements to be analyzed:

- Percentage of vegetation cover, average height and abundance of each species;
- Structure and composition of the thicket or patch of vegetation;
- Impact of the magnitude, duration and return periods of high and low flows in the vegetation.

Recommended Information:

- List of species of aquatic and riparian vegetation and their spatial distribution of vegetation on the riverbed and the adjacent riverbank forest;
- Hydrologic description from hydrometric information, and high and low flow levels reached in the channels;
- Transverse slopes on both margins, exposure of slopes, altitude, vertical height and horizontal distance from the water level to the upper and

lower limits of each vegetation zone, characteristics of the valley where the river is found and other characteristics of adjacent vegetation;
- Substrate type and characteristics of the soil in each vegetation zone;
- Signs of erosion, sediment deposits, and other disturbances present (including anthropogenic) in each vegetation zone and signs of historical changes of the channel position.

Products:

- Identification of the composition and structure of populations and communities of species of aquatic and riparian vegetation;
- Development of a profile of aquatic (macrophytes and algae) and riparian (grasses, shrubs and trees) vegetation, associating them with areas of distinct flood levels equivalent to 5 times the width or average amplitude of the channel;
- Identify the magnitude, duration and periods of return of flows necessary to inundate each of the zones or bands of the channel where there is riparian vegetation.

MACROINVERTEBRATES

Analysis objectives:

- Describe the structure, composition and spatial and temporal distribution of aquatic macroinvertebrates;
- Link and identify hydrologic and hydraulic requirements necessary for the formation and configuration of aquatic habitat that supports macroinvertebrate communities;
- Retrospective and trend analysis from historical presence information (list of species).

Elements to be analyzed:

- Index of relative abundance of each species of macroinvertebrates;
- Structure and composition of populations and communities of macroinvertebrate and the habitats in which they live;
- Impact of the magnitude, duration and return periods of high and low flows on macroinvertebrates.

Recommended Information:

- Historical and stream list of species (or at least families) of aquatic macroinvertebrates and their spatial and temporal distribution in the epicontinental aquatic habitat;
- List of substrate type and spatial and temporal distribution of habitat;
- Hydrologic description from hydrometric information, and level reached by high and low flows in the channels.

Products:

- Identification of the composition, structure and abundance of populations and communities of aquatic macroinvertebrates;
- List of sensitive species selected on the basis of quantification of tolerance intervals of the hydraulic habitat in each aquatic habitat identified.

FISH

Analysis objectives:

- Characterize the structure, composition, and spatial and temporal distribution of fish.
- Link and identify critical hydrologic and hydraulic parameters associated with their preferred habitat, for each species;
- Evaluate the ecological importance of each species and the sensitivity associated with its life cycle;
- Evaluate the importance, ecological and biological integrity, and sensitivity of the river;
- Retrospective and trend analysis based on information of historical presence (list of species).

Elements to be analyzed:

- Indices of natural wealth, biodiversity, structure and composition (Example: IBI);
- Ecological requirements of fish;
- Impact of the magnitude, duration and return periods of high and low flows on fish.

Recommended information:

- List of historical and existing ichthyofauna present at the site of reference;
- List of hydraulic and physical habitat available for the entire cycle life of the ichthyofauna in each of the geomorphological areas in the channel.

Products:

- Inventory of all fish species, their ecological importance and degree of sensitivity;
- Identification of species as bio-indicators of the ecological state of the river;
- Hydraulic and physical habitat (geomorphological) required by ichthyofauna at different stages of life.

SOCIAL ASPECTS

Analysis objectives:

- Provide information on riparian resources and the use of river water by rural communities and the relevance for maintenance of their livelihoods.

Elements to be analyzed:

- Identification of user groups;
- Description of the use and consumption patterns associated with the resource availability, and its goods and services (quantity, seasonality, substitutes and frequency);
- Relation of goods and services with the flow regime in the UECE;
- Identification of threats to goods and services.

Recommended Information:

- List of localities and populations in the UECE;;
- Identification of water uses and associated resources such as water supply, fishing, tourism, laundry or similar practices, recreation, protection against extreme events, material supplies, wastewater facilities or watering holes.

Products:

- Population census of water users;
- Pattern and volume of use or consumption;
- Goods or services provided by riparian resources.

6. Validity

This International Standard shall enter into force 60 days after the publication of its publication in the Official Journal of the Federation.

7. Bibliography

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8. Agreement with international standards

This Mexican Standard does not match any international standard, since none exist on the subject.

INFORMATIVE APPENDIX G

GENERAL CONSIDERATIONS

To apply the methodology described in this appendix for the determination of the ecological flow regime in streams or national bodies of water at the hydrological basin, level knowledge of the original historical or natural flow is required, as well as the calculation of annual and monthly means. Here is a suggested procedure for obtaining this information:

1. Location of Hydrological Region according to the document published and updated by the National Water Commission (citations Water Statistics and official published availability studies.) Check the page to review the latest version. The first number of the codefor the hydrometric gauging stations corresponds to the hydrological region to which they belong.

2. Limits of basins and sub-basins. - Based on the 731 availability studies published in the Official Journal of the Federation. Location of CONAGUA hydrometric stations in the BANDAS (Database of surface water, with access to CONAGUA and IMTA pages.

(http://www.conagua.gob.mx/CONAGUA07/Contenido/Documentos/Portada%20BANDAS.htm)

Consultation on the code and description for each gauging station.

Obtainment of geographic coordinates for its location in a geographic information system.

3. Requisition for information on hydrometric stations from CFE.

4. Based on the ordering of historical daily means, construct hydrographs of 365 day intra-annual, annual, and monthly variations.

5. Locate the hydraulic infrastructure, including date of construction and/or start of operation and identify periods prior to and after alteration, years of records in each period and construct hydrographs.

6. To have a better reference for the methodologies of Appendices C, D, E and F, the numerical examples found in the "Guía para la aplicación de la norma mexicana para la determinación del régimen de caudal ecológico en cuencas hidrológicas" (*"Guide to the Implementation of the Mexican Standard for Determination of the Ecological Flow Regime in Hydrological Basins"*) may be consulted. It is located on the web portal of CONAGUA (http://www.conagua.gob.mx/).

Mexico, DF, September 20, 2012
General Director, **CHRISTIAN TURÉGANO ROLDÁN**
Rubric

II DECLARATORIA DE VIGENCIA DE LA NORMA MEXICANA NMX-AA-159-SCFI-2012

Publicada en el Diario Oficial de la Federación (DOF) el 20 de septiembre de 2012.

Al margen un sello con el Escudo Nacional, que dice: Estados Unidos Mexicanos.- Secretaría de Economía.- Subsecretaría de Competitividad y Normatividad.- Dirección General de Normas.- Dirección General Adjunta de Operación.- Dirección de Normalización.

DECLARATORIA DE VIGENCIA DE LA NORMA MEXICANA: NMX-AA-159-SCFI-2012

QUE ESTABLECE EL PROCEDIMIENTO PARA LA DETERMINACIÓN DEL CAUDAL ECOLÓGICO EN CUENCAS HIDROLÓGICAS.

La Secretaría de Economía, por conducto de la Dirección General de Normas, con fundamento en lo dispuesto por los artículos 34 fracciones XIII y XXXI de la Ley Orgánica de la Administración Pública Federal; 51-A, 51-B y 54 de la Ley Federal sobre Metrología y Normalización, 45 y 46 del Reglamento de la Ley Federal sobre Metrología y Normalización y 19 fracciones I y XIV del Reglamento Interior de esta Secretaría y habiéndose satisfecho el procedimiento previsto por la ley de la materia para estos efectos, expide la declaratoria de vigencia de la norma mexicana que se enlista a continuación, misma que ha sido elaborada y aprobada por el Comité Técnico de Normalización Nacional de Medio Ambiente y Recursos Naturales (COTEMARNAT) lo que se hace del conocimiento de los productores, distribuidores, consumidores y del público en general. El texto completo de las normas que se indican pueden ser adquiridas gratuitamente en la biblioteca de la Dirección General de Normas de esta Secretaría, ubicada en Puente de Tecamachalco número 6, Lomas de Tecamachalco, Sección Fuentes, Naucalpan de Juárez, código postal 53950, Estado de México o en el catálogo electrónico de la Dirección General de Normas:

http://www.economia-nmx.gob.mx/normasmx/index.nmx

La presente Norma Mexicana entrará en vigor 60 días naturales después de la publicación de esta declaratoria de vigencia en el Diario Oficial de la Federación.

CLAVE O CÓDIGO	TITULO DE LA NORMA
NMX-AA-159-SCFI-2012	QUE ESTABLECE EL PROCEDIMIENTO PARA LA DETERMINACIÓN DEL CAUDAL ECOLÓGICO EN CUENCAS HIDROLÓGICAS
Objetivo y campo de aplicación La presente Norma Mexicana establece el procedimiento y especificaciones técnicas para determinar el régimen de caudal ecológico en corrientes o cuerpos de agua nacionales en una cuenca hidrológica. Esta norma mexicana aplica a todos aquellos que realicen estudios para solicitar asignaciones, construir infraestructura, realizar trasvases entre cuencas, similares a Evaluación de Impacto Ambiental (EIA). Así como para todas las corrientes o cuerpos de agua, cuyos acuerdos de disponibilidad del agua publicados en el Diario Oficial de la Federación (DOF), no consideren un caudal para la conservación de ecosistemas acuáticos.	
Concordancia con normas internacionales Esta Norma Mexicana no coincide con ninguna norma internacional, por no existir norma internacional sobre el tema tratado.	

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- Ley Federal sobre Metrología y Normalización, publicada en el Diario Oficial de la Federación el 1 de julio de 1992 y el decreto por el que se reforman, adicionan y derogan diversas disposiciones a la Ley, publicado en el Diario Oficial de la Federación el 30 de abril de 2009.

- Ley Orgánica de la Administración Pública Federal, publicada en el Diario Oficial de la Federación el 29 de diciembre de 1976 y el decreto por el que se reforman, adicionan y derogan diversas disposiciones a la Ley, publicado en el Diario Oficial de la Federación el 17 de junio de 2006.

- Ley General del Equilibrio Ecológico y Protección al Medio Ambiente, publicada en el Diario Oficial de la Federación el 28 de enero de 1988 y el decreto por el que se reforman, adicionan y derogan diversas disposiciones a la Ley, publicado en el Diario Oficial de la Federación el 30 de agosto de 2011.

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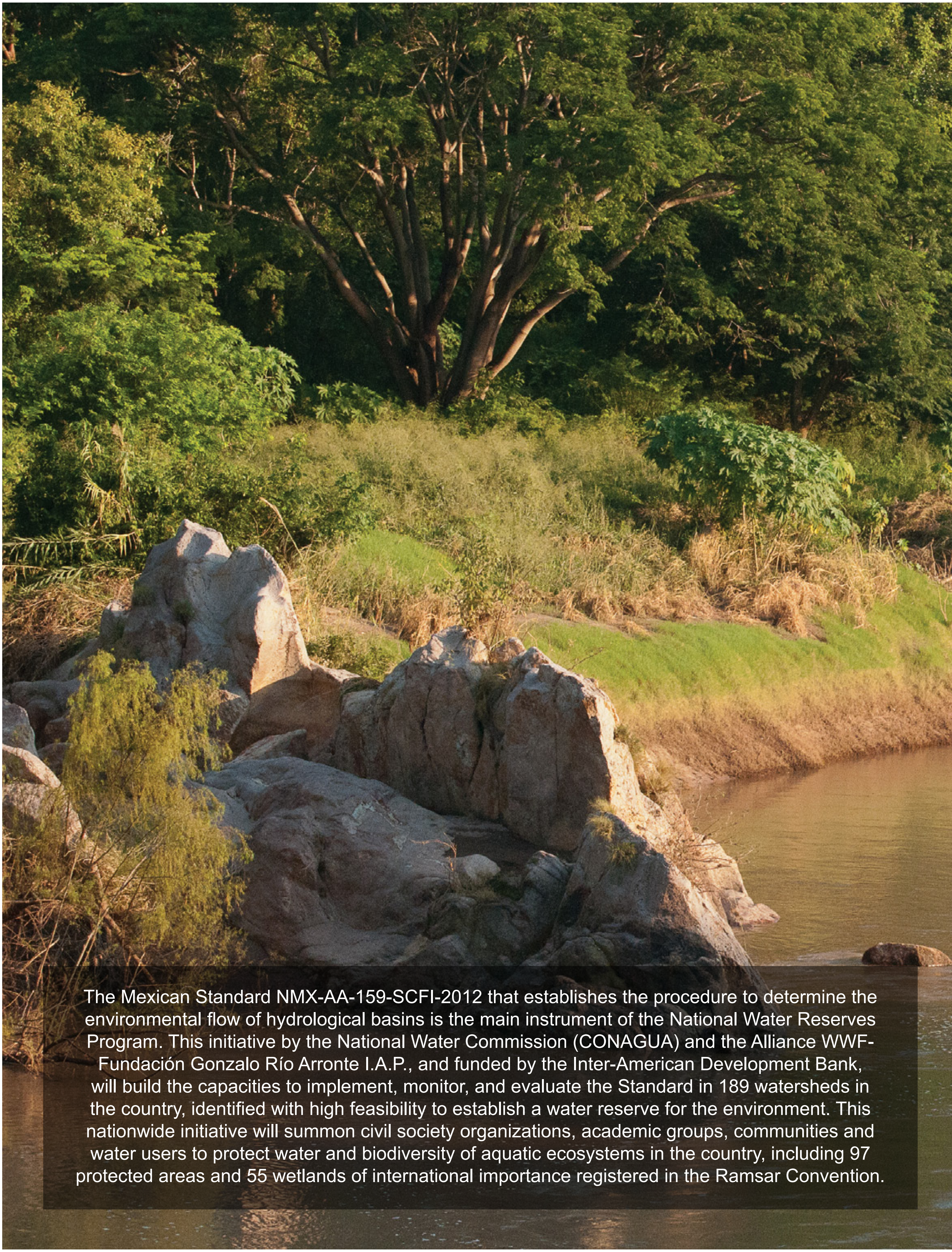
México, D.F., a 29 de agosto de 2012
El Director General de Normas y Secretariado Técnico de la Comisión
Nacional de Normalización, **CHRISTIAN TURÉGANO ROLDÁN**
Rúbrica

NOTES



The Mexican Standard NMX-AA-159-SCFI-2012 that establishes the procedure to determine the environmental flow of hydrological basins is the main instrument of the National Water Reserves Program. This initiative by the National Water Commission (CONAGUA) and the Alliance WWF-Fundación Gonzalo Río Arronte I.A.P., and funded by the Inter-American Development Bank, will build the capacities to implement, monitor, and evaluate the Standard in 189 watersheds in the country, identified with high feasibility to establish a water reserve for the environment. This nationwide initiative will summon civil society organizations, academic groups, communities and water users to protect water and biodiversity of aquatic ecosystems in the country, including 97 protected areas and 55 wetlands of international importance registered in the Ramsar Convention.