



Evaluation of Environmental Flows in Rivers Using Hydrological Methods (Case study: The *Barandozchi* River- *Urmia* Lake Basin)

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Introduction Development of water resources projects are accompanied by several environmental impacts, among them, the changes in the natural flow regime and the reduction of downstream water flows. With respect to the water shortages and non-uniform distribution of rainfall, sustainable management of water resources would be inevitable. In order to prevent negative effects on long-term river ecosystems, it is necessary to preserve the ecological requirements of the river systems. The assessment of environmental flow requirements in a river ecosystem is a challenging practice all over the world, and in particular, in developing countries such as *Iran*. Environmental requirements of rivers are often defined as a suite of flow discharges of certain magnitude, timing, frequency and duration. These flows ensure a flow regime capable of sustaining a complex set of aquatic habitats and ecosystem processes and are referred to as "environmental flows". There are several methods for determining environmental flows. The majority of these methods can be grouped into four reasonably distinct categories, namely as: hydrological, hydraulic rating, habitat simulation (or rating), and holistic methodologies. However, the current knowledge of river ecology and existing data on the needs of aquatic habitats for water quantity and quality is very limited. It is considered that there is no unique and universal method to adapt to different rivers and/or different reaches in a river. The main aim of the present study was to provide with a framework to determine environmental flow requirements of a typical perennial river using eco-hydrological methods. The *Barandozchi* River was selected as an important water body in the *Urmia* Lake Basin, *Iran*. The preservation of the river lives, the restoration of the internationally recognized *Urmia* Lake, and the elimination of negative impact from the construction of the *Barandoz* dam on this river were the main concerns in this study.

Materials and Methods: With lack of ecological data, the environmental requirements of the *Barandozchi* River were investigated using five eco-hydrological methods (1- Tennant, 2- Tessman, 3- Flow Duration Indices, 4- FDC shifting, 5- DRM). Some of these methods are too simplistic and do not take into account the direct hydro-ecological interactions (e.g. Tennant method), and some have been developed for a specific country/region (e.g., DRM), and need to be adapted to a different physiographic environment before they can be reliably applied. Two ecological friendly models GEFC, and DRM were tested to estimate the environmental flow of this river. The results were compared with corresponding flows allocated for the release from the *Barandoz* Dam (currently under construction).

Results and Discussion: The prediction of the mean annual environmental flows from five eco-hydrological methods are presented and compared with the corresponding value reported in the downstream dam's documents. The ultimate decision making based on the potential flows in the river, the environmental class of the river management, and engineering judgment is also recommended for the flows in the river towards the *Urmia* Lake. The results indicated that the flow allocation for the river environment (4% of mean annual flows) is not sufficient to meet the minimum flow requirements for any of the targeting species in the river ecosystem. In order to maintain the *Barandozchi* River at minimum acceptable environmental status (i.e. Class C of environmental management), an average annual flow of 1.9 m³/s (26% MAR) are to be provided. The distribution of monthly flow rates in the river is also recommended for sustaining the *Barandozchi* River life.

Conclusion: The provision for the minimum ecological flows was investigated in the *Barandozchi* River ecosystem. The results indicated that, in order to maintain the *Barandozchi* River at minimum acceptable environmental status (i.e. Class C), an average annual flow of 1.9 m³/s (26% MAR) are to be provided along the river towards the internationally recognized *Urmia* Lake, in *Iran*. Considering the construction of the *Barandoz* dam on this river, the pre-determined environmental flow releases from the dam are to be revised in order to increase the order of flows from 4% to 26% or more. Further investigation is necessary to take into account for the targeting riverine species and for the saving of the *Urmia* lake ecosystem. It is noted that minimum flow

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requirements are to be allocated in critical months of the year or during drought period of the river basin. Water leasing from agricultural users is an option or a necessary action whenever long-term environmental damages to the river ecosystem must be avoided.

Keywords: Environmental flow, Eco-Hydro methods, Barandozchi River, Urmia Lake.