Key questions to be addressed
(Adapted from Richter, Brian D., Andrew T. Warner, Judy L. Meyer, Kim Lutz. (2006) A collaborative and adaptive process for developing environmental flow recommendations. River Research and Applications 22:3, 297-318)

Hydrology

1. Do stream gauges exist along the river, and if so, where are they located, who maintains them, and how long have they been in operation?
2. What are/were the typical seasonal patterns of natural river flow variation (e.g. when do higher flows tend to occur, when do the lowest flows occur)?
3. To what extent have the low, high pulse, and flood flows in the river changed over time in response to human influences? Have extreme low flows become more frequent or extreme? How do hydrographs from recent years compare to predevelopment hydrographs?
4. What are the primary human influences on the flow regime, and where do these impacts occur? Do certain human impacts appear to dominate over other human influences?
5. What types of water development activities are planned for the future, and how might those developments influence river flows?
6. How important are ground water contributions to base flows? What is the nature of hydraulic connections between river stage and alluvial water table levels? How might these connections be altered by future water developments?

Suggested approaches:

- Prepare a schematic drawing of the drainage network, noting the mean annual flow and drainage basin area at all available stream gauge stations.
- Provide a tabular summary of water uses and water structures, at the finest level of detail available.
- Prepare "typical" hydrographs (both annual and decadal hydrographs) for undeveloped and developed conditions at all river and lake monitoring stations.
- Categorize the natural hydrologic regime into ecological flow components: subsistence flows, base flows, high pulse flows, overbank flows. Using the Indicators of Hydrologic Alteration (IHA) software, estimate quantitative values for each of these components under natural, historic, present, and future conditions (if hydrologic simulation data are available). Assess changes in the magnitude, duration, timing, and frequency of each flow component.
- Prepare flow duration curves for undeveloped and developed conditions at all stream gauges.
- Characterize typical groundwater-surface water interactions using monitoring well data or other sources of information.

Hydraulics

1. Has any hydraulic modeling been performed for the river? Has any flood hazard mapping been undertaken?
2. How well are relationships between river stages (water elevations) and river flow levels understood?
3. How well are relationships between river flow and the distribution of velocities and depths in the river channel understood?
4. Is there longitudinal (upstream to downstream) connectivity in flow or are there major discontinuities (i.e. diversion dams), and if so where?
5. Has the lateral connectivity between the river and its floodplain been altered in any way?

Suggested approaches:

- Develop river stage-discharge relationships (e.g., at flow monitoring stations or from hydraulics models).
- Plot the relationship between flow and estimated percent floodplain inundated at representative river transects (e.g., at stream gauges or from aerial photos).
- Develop flow depth and velocity estimates across river transects (e.g., at stream gauges or using hydraulics models)

Geomorphology

1. Have any topographical surveys been conducted of the river channel or floodplain (including any surveying for bridges, roads, floodplain mapping, etc.)?
2. Is the channel and floodplain system in dynamic equilibrium or disequilibrium? Is the sediment input to each segment in equilibrium with the capacity of the channel to transport it through the segment? Are there detectable trends in the elevation of the river bed or lake bottom, indicating degradation or aggradation? Has the river's longitudinal profile changed over time?
3. Has the channel or floodplain width changed over time?
4. Has the channel's planform changed over time; such as between meandering and braided forms?
5. Has the size distribution of stream bed sediments changed over time?
6. Has the availability of in-stream physical habitats changed over time (e.g. changes in availability of pools or riffles)?
7. Is lateral channel migration or bar formation important ecologically (e.g. to support riparian plant communities)?
8. Has human activity and land use significantly altered the stream channel and floodplain morphology and processes?

Suggested approaches:

- Plot the river's present-day longitudinal profile from topographic maps or field survey information
- Characterize historical changes in longitudinal river slope, if adequate data are available (e.g., at multiple river flow monitoring station locations).
- Review historical aerial photographs to assess changes in river plan form and floodplain over time
- Assess changes in channel cross-sectional shape, if data are available (e.g., at stream gauges)
- Develop sediment budget estimates for appropriate representative time periods, such as historic, pre-dam agricultural, and post-dam periods.
- Estimate flows necessary to entrain river sediments (to maintain desired streambed composition or move sediment downstream to lake).
- Estimate channel forming flows necessary to maintain desired channel geometry.
- Estimate channel migration flows needed to sustain floodplain development and riparian ecosystem.

Water quality

1. Have water quality data been collected for the river, and if so, by whom, where, for how long, and of what type?
2. How do water quality conditions vary spatially in the river?
3. What is known about water quality problems in the river?
4. Is wastewater discharged into the river? Where, and how much? What proportion of the low flows in the river arises from upstream wastewater discharges?
5. What is known about daily, seasonal, annual fluctuations in key parameters such as dissolved oxygen or temperature in the river?
6. How do human activities affect water chemistry, temperature or dissolved oxygen in the river?
7. What water quality components are of greatest concern to the target organisms, life stages or riverine processes (e.g. dissolved oxygen, suspended sediment, temperature, chemical elements, nutrients)? Are species distributions or abundances thought to be affected by water pollution?
8. Is large woody debris an important component of the aquatic ecosystem?
9. Are any invasive plant species an issue of concern?

Suggested approaches:

- Characterize natural and post-development patterns of water temperature, including seasonal and diurnal fluctuations.
- Characterize natural and post-development patterns of dissolved oxygen in the water, including seasonal and diurnal fluctuations.
- Identify known relationships between reservoir releases and discharge of contaminants present in the reservoir.

Freshwater ecology

1. What type of biological data have been collected for the river? Who collected these data, over what time frame, and how often?
2. Has the abundance or distribution of certain species changed over time? Are these changes thought to be linked to changes in river flow or water quality? Are data available to document these trends?
3. What species (fish, birds, mammals, invertebrates, aquatic plants or riparian vegetation) are of greatest concern from either ecological or socio-economic or recreational standpoints?
4. What is known about the linkages between river flow and life histories of aquatic species? What times of year are most critical for indicator species, life stages or species assemblages?
5. Can the flow needs of certain indicator species be used to represent the flow needs of assemblages of organisms (e.g. fish communities, riparian vegetation)?
6. If the river flow regime has been altered by human influences, are necessary flow conditions still properly sequenced to enable successful life cycle completion for indicator species?
7. Which habitats are most limiting, and what is the importance of drought, flooding and intermediate flow conditions for developing and maintaining these habitats?
8. Are aquatic floodplain habitats critical for maintaining fish populations in rivers?
9. Is the aquatic ecosystem dependent upon energy subsidies (e.g. detrital matter) that are brought into the river from the floodplain during floods?
10. Do certain species require particular flow levels to facilitate movements in the river?
11. If reservoir releases are proposed in order to provide recommended flows, could there be effects on the ecology and fisheries in the reservoir?

Suggested approaches:

- Define life history stages for a diverse cross-section of species, such as aquatic plants, invertebrates, and resident and anadromous fishes, along with any known relationships to flow components and their seasonality. Specific life history aspects to consider include adult foraging, survival, and gonadal development; spawning migration and activity; egg, larva, and juvenile development; juvenile growth and survival.
- Define relationships between flow components and maintenance or access to critical habitats for completion of life history stages for key species.
- Describe ways in which flow components will influence primary productivity, decomposition processes, and nutrient dynamics.

Riparian ecology

1. Have the riparian plant communities or distributions of riparian plant or animal species been surveyed or characterized?
1. Have they changed over time?
2. What is known about relationships between river flows, alluvial water table levels, floodplain inundation patterns, and the influence of these hydrologic conditions on riparian plants or animals?
3. Do certain riparian plants or animals depend upon physical habitat conditions that are shaped by river flows? Is lateral channel migration or bar formation important in forming these physical habitats?

Suggested approaches:

- Define life history stages for a diverse cross-section of riparian obligate flora and fauna species, along with known relationships to flow components and the seasons in which they occur.
- Define relationships between flow components and maintenance or access to riparian habitat conditions.
- Describe relationships between flow components and vulnerability to disturbances such as fire or introduced species invasions.
- Describe ways in which flow components will influence primary productivity, decomposition processes, and nutrient dynamics.