2-9-09

Texas Instream Flow Program
Middle & Lower Brazos Study Design Workgroup

Indicators

Biology		
Category	Indicator	Explanation
Instream Biological Communities	Native Richness	Richness, or the number of species or taxa, is a measure of community health, can be applied at a variety of scales (reach to basin to statewide), and can be related to modifications in flow. May also use proportions such as the proportion of native to non-native species.
	Relative Abundance	The number of organisms of a particular species as a percentage of the total community.
	Fish • Flow sensitive species • Sport fishes • Prey species • Imperiled species • Intolerant species	Fish are useful indicators because: • they occupy a range of habitats and have a variety of life histories that are generally known; • their position at various levels of the aquatic food chain provides an integrative view of the watershed; • they are useful for examining both direct toxicity and stressful conditions by looking at indicators such as missing species or depressed growth and reproduction; • they are valued by the public; There are many species of fish in the river and all of them cannot be studied individually. Those that may warrant study include: flow sensitive species; sport fishes; prey species; imperiled species; and intolerant species.
	Benthic invertebrates • mussels • riparian plants • other vertebrates	These may be appropriate as indicators.
Instream Habitat	Habitat Quality and Quantity for Key Species	Involves relating suitable habitat (microhabitat) and flow for key species. Habitat attributes may include current velocity, depth, substrate and cover; other attributes may be important for some species.
	Mesohabitat Area and Diversity	This indicator stems from the knowledge that diverse habitats support diverse communities. Mesohabitat analysis provides a quantifiable relationship between larger scale habitat (e.g. riffles, runs, pools) area and flow; habitat diversity can be derived from same data. Uses biological data for all species in a community (e.g., fish species) to define the attributes of each mesohabitat.

Biology (continued)		
Category	Indicator	Explanation
Riparian Habitat	Vegetation • Age class distribution of riparian plant species • Riparian species richness and diversity • Density • % Canopy cover	These are key components in assessing the diversity, health, and functionality of riparian habitat and ensuring that adequate riparian species are present for recruitment and maintenance of the ecosystem. Riparian plants typically must maintain contact with the water table, so their presence and diversity is an important indicator of soil moisture (water table) characteristics. The listed vegetation parameters can be correlated with important riparian functions, such as stream bank stabilization, temperature dynamics, and nutrient cycling.
	Soils • Riparian soil types	In the absence of riparian vegetative indicators, soil characteristics identified by the soil survey database can be used to determine past or present hydrologic influence and hence historical riparian area extent.
	Hydrology • Gradient of inundation, base flow levels	Periodic occurrence of flood (overbanking) flows, associated channel dynamics, and the preservation of base flows capable of sustaining high floodplain water tables are essential to maintaining the health of riparian ecosystems. Ground water depths can be sampled at each study reach and coupled with surface water data to produce a probability of inundation curve. Overbanking flow requirements can be modeled.
Hydrology / Hydraulics		
Category	Indicator	Explanation
Flow regime components	Overbank flows (frequency, timing, duration, rate of change, and magnitude)	Infrequent, high magnitude flow events that enter the floodplain. • Maintenance of healthy riparian areas. • Transport of sediment and nutrients to/from floodplain. • Connectivity of riparian and floodplain habitats to the river channel. • Recharge alluvial aquifer.
	High pulse flows (frequency, timing, duration, rate of change, and magnitude)	Short duration, high magnitude within channel flow events • Maintain sediment transport and physical habitat features of the river channel. • Provide longitudinal connectivity along the river corridor for many species (e.g., migratory fish).
	Base habitat flows (frequency, timing, duration, range of change, and magnitude)	Range of average or “normal” flow conditions. • Provide instream habitat quantity and quality needed to maintain the diversity of biological communities. • Maintain water table and support/maintain healthy riparian vegetation.
	Subsistence flows (frequency, timing, duration, rate of change, and magnitude)	Low flows maintained during times of very dry conditions. • Maintain water quality standards. • Prevent loss of aquatic organisms. • Prevent loss of riparian vegetation.

Hydrology / Hydraulics (continued)		
Category	Indicator	Explanation
Natural variability	Natural	Determination of the natural variability of the above indicators, based on the older portions of gage records, presumably less impacted by human activity. The exact time period may vary by site.
	Current	Variability of the above indicators based on the last 20-25 years of gage records.
Sources of instream flow	Total flow gain or loss in section of river	Difference in the amount of water entering and leaving a specific section of the river channel. Sources of gains include inflow from tributaries, alluvial and deeper aquifers, and discharges to the river. Sources of losses include direct evaporation, transpiration from riparian areas, diversions, and recharge of alluvial and deeper aquifers. Indicator may be influenced by shallow groundwater surface elevation and hydraulic head of deeper aquifers.
Water Quality		
Category	Indicator	Explanation
Nutrients	Nitrogen • Organic • Nitrate plus nitrite • Ammonia • Total Phosphorus • Filterable reactive • Total	The nutrients nitrogen and phosphorus are essential for plant growth. High concentrations indicate potential for excessive weed and algal growth. Total nutrients are made up of a dissolved component (e.g. nitrate plus nitrite, ammonia and filterable reactive phosphorus) and an organic component, which is bound to carbon (e.g. organic nitrogen). Nutrients in the dissolved state can be readily used by plants.
Oxygen	Dissolved oxygen	Oxygen is essential for both plants and animals. There is often a relationship between discharge and dissolved oxygen concentrations. Decreased dissolved oxygen can be harmful to fish and other aquatic organisms. Nonpoint-source pollution as well as the decomposition of leaf litter, grass clippings, sewage, and runoff from feedlots can decrease the amount of dissolved oxygen in water. Dissolved oxygen is measured in milligrams per liter (mg/L). Expected levels: 4.0 to 12.0 mg/L
Temperature	Temperature	Aquatic organisms are dependent on certain temperature ranges for optimal health. Temperature affects many water parameters, including the amount of dissolved oxygen available, the types of plants and animals present, and the susceptibility of organisms to parasites, pollution, and disease. Causes of water temperature changes include weather conditions, shade, and discharges into the water from urban sources or groundwater inflows. Temperature is measured in degrees Celsius (°C). Seasonal trends: May to October: 22 to 35°C, November to April: 2 to 27°C. Low flow conditions can also have an influence on temperature.

Water Quality (continued)		
Category	Indicator	Explanation
Water clarity	Turbidity	A measure of light scattering by suspended particles in the water column provides an indirect indication of light penetration.
Salinity	Conductivity	A measure of the amount of dissolved salts in the water, and therefore an indicator of salinity. In fresh water, low conductivity indicates suitability for agricultural use. In salt waters low conductivity indicates freshwater inflows such as storm water runoff.
Recreational health	Bacteria	*E. coli* and Enterococci bacteria are measured to determine the relative risk of swimming (contact recreation), depending on whether the water body is fresh or marine. These bacteria originate from the wastes of warm-blooded animals. The presence of these bacteria indicates that associated pathogens from these wastes may be reaching a body of water. Sources may include inadequately treated sewage, improperly managed animal waste from livestock, pets in urban areas, or aquatic birds and mammals.
Geomorphology		
Category	Indicator	Explanation
Bank Stability	Rate of lateral channel migration	Rate of lateral movement of channel across valley. Some migration of the channel is crucial to support diverse riparian habitats and a healthy ecosystem.
	Rate of channel avulsion	Rate of creation of channel cut-offs. Cut-offs, in the form of oxbow lakes, back water areas, and abandoned channels, provide distinct and important habitats.
	Rate of bank erosion	The rate at which flows erode the sides of channels. This will vary by bank material and condition of the banks (vegetated, saturated, etc.).
Channel maintenance	In-channel bars (area, configuration, sediment size)	Sediment bars are an important in-channel bed form. Flow across these features provides a diversity of hydraulic conditions. Bar formation, in combination with opposite-bank erosion, is the driving process behind channel migration. As bars age, they gradually create new areas of floodplain and riparian habitat.
	Meander pools (depth)	Meander pools are another important in-channel bed form. Deep pools provide diverse hydraulic conditions and cover for some species. They also provide refuge habitat for many species during low flow periods.
Alluvial and associated aquifers	Total flow gain or loss in section of river	Difference in the amount of water entering and leaving a specific section of the river channel. Sources of gains include inflow from tributaries, alluvial and deeper aquifers, and discharges to the river. Sources of losses include direct evaporation, transpiration from riparian areas, diversions, and recharge of alluvial and deeper aquifers. Indicator may be influenced by shallow groundwater surface elevation and hydraulic head of deeper aquifers.

Geomorphology (continued)		
Category	Indicator	Explanation
Flood impacts	Stage (at USGS gage locations)	The National Weather Service provides flood impact summaries for most USGS streamflow gage sites, based on water surface elevation or "stage." These summaries provide an estimate of impacts of overbank flows.
Connectivity		
Category	Indicator	Explanation
Riparian zone	Total area inundated	The amount of out of channel area inundated by an overbank flow of a particular magnitude.
	Habitat area inundated	The amount of habitat area of a particular type that is inundated by a particular magnitude of overbank flow.
Lateral connectivity	Connection to river (frequency, duration, and timing)	Periodic connectivity of the river with oxbow lakes, backwaters, and other floodplain habitats is important to maintain the health of these areas and the organisms that depend on them.
Groundwater/ surface water interaction	Total flow gain or loss in section of river	Difference in the amount of water entering and leaving a specific section of the river channel. Sources of gains include inflow from tributaries, alluvial and deeper aquifers, and discharges to the river. Sources of losses include direct evaporation, transpiration from riparian areas, diversions, and recharge of alluvial and deeper aquifers. Indicator may be influenced by shallow groundwater surface elevation and hydraulic head of deeper aquifers.
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Indicators for Other Objectives

The following objectives separate from a discipline were agreed to by the group, but indicators were not considered necessary as they were adequately covered by other indicators.

- Define/determine current, historical and natural conditions in each flow regime component (overarching objective)
- Evaluate relationships between flow regimes and economic and social uses, including recreational use
- Consider how water planning studies and instream flow studies will impact and interact