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Decision Points Relevant to using Hydrology Data to Quantify Environmental Flow Recommendations

Prepared for
Senate Bill 3 Science Advisory Committee

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This document introduces common decision points when using hydrologic data to help define environmental flow recommendations. Clarifying examples are provided in the descriptions of some decision points. These are solely intended as illustrative examples and should not be construed as recommendations.

For convenience, the decision points discussed herein are collected into two groups: (1) decision points that are independent of the quantification method used, and (2) decision points that are specific to the Hydrology based Environmental Flow Regime (HEFR) method presented by TPWD staff to the Science Advisory Committee (SAC) on October 1, 2008. However, it should be recognized that this designated bright line distinction is not always black and white. Some aspects of decision points that are listed as specific to the HEFR Method may be important to other (as yet undefined) methods as well.

Many of the decision points described herein have been discussed and addressed in other contexts, such as the Desk-Top Methodology review recently completed by the Texas Commission on Environmental Quality (TCEQ), the ongoing work being performed in support of the LCRA-SAWS Water Project, and other applications of IHA throughout the country. Specific examples can be provided upon request.

In this document, the phrase "Instream Flow Components" (IFCs, commonly used in the Texas Instream Flow Program) is used synonymously with "Environmental Flow Components" (EFCs, used in the Indicators of Hydrologic Alteration, IHA, software). However, when specifically referring to the Environmental Flow Components function in IHA, it is only correct to use the acronym "EFC."

IHA version 7 was used to develop this document[1]. In this document, the word "analyst" is used to generically refer to an appropriate decision maker(s). In the real world, this may include the Environmental Flows Advisory Group, the Science Advisory Committee, the Basin and Bay Expert Science Team, Basin and Bay Area Stakeholder Committee, or other person or entity.

TPWD staff is happy to provide additional details on items of interest. TPWD staff is similarly happy to provide perceived advantages and disadvantages of various options upon request.

[1] http://www.nature.org/initiatives/freshwater/conservationtools/art17004.html

To assist the reader with the terminology used herein, Figure 1 is a copy of the example flow regime matrix presented to the SAC on October 1, 2008 with salient features labeled.

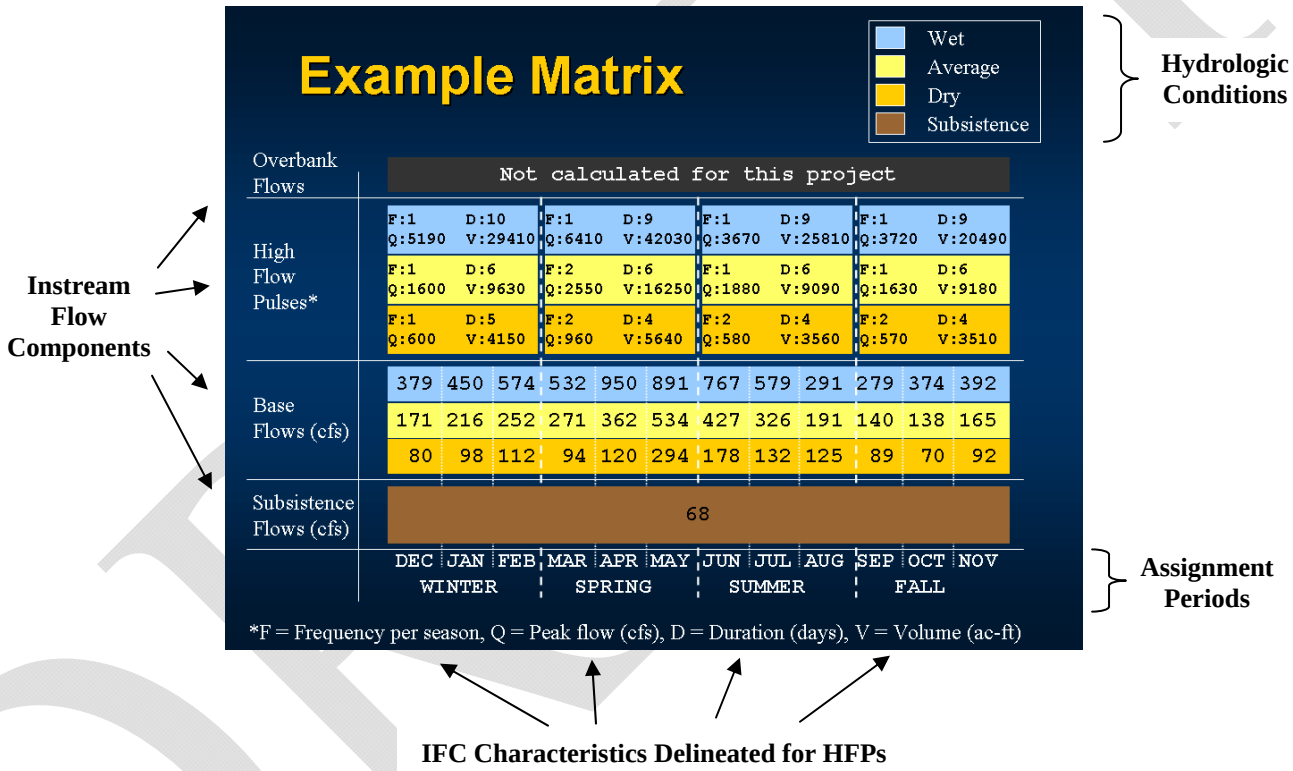

Figure 1. Visual Glossary

Decision Points Independent of the Quantification Method Used

TPWD staff expects these decision points to arise when using any hydrology based method.

1. Number of Instream Flow Components

The analyst must decide how many IFCs to use and what aspects of the hydrograph they should represent. The Texas Instream Flow Program (Senate Bill 2) uses four IFCs (subsistence flows, baseflows, high flow pulses, overbank flows). IHA has five (extreme low flows, low flows, high flow pulses, small floods, large floods), but can easily be constrained to fewer components.

2. Hydrologic Period of Record

In any hydrology based method, the analyst must decide whether or not to use the entire data record, and, if not, the analyst must decide which period to use. A common example is "pre human impact" (sometimes referred to as "naturalized flows") versus "post human impact." For example, the Desk-top Methodology Technical Review Group (TRG) concluded that "whenever feasible, historical pre-impact flow records should provide the basis for evaluating environmental flow targets." A related issue is where to "break" the flow record if pre or post human impact is desired. Statistical tools, such as IHA and TX-HAT[2], have specific capabilities to help guide this decision. The analyst may also encounter breaks in a flow record that require concomitant decisions, such as choosing a period of record without a flow break or filling in breaks using a nearby gage with an acceptable flow correlation. Finally, the analyst must decide if the desired period of record is long enough to support a hydrologic analysis (e.g., the IHA manual generally recommends at least twenty years). If not, then alternative methods are necessary.

3. Hydrologic Condition

This issue is relevant if the analyst believes that wet periods should have different environmental criteria than dry periods. The Consensus Environmental Flow Planning Criteria has a similar concept, referred to as three "zones." If multiple hydrologic conditions (or "zones" or "climatic conditions") are desired, the analyst must (1) decide how many hydrologic conditions to employ, (2) define a "trigger" to determine which hydrologic condition a location is in at a given time, and (3) perhaps assign desired frequencies to each hydrologic condition. An example could be three hydrologic conditions, with dry occurring 25% of the time, average occurring 50% of the time, and wet occurring 25% of the time, with the trigger being nearby streamflows. For example, if a nearby unimpacted tributary is flowing below its historical 25th percentile of flow, then the hydrologic condition at the environmental flow location would be "dry." Examples of triggers include (1) reservoir storage (i.e., percent full), (2) streamflow at the location of interest, (3) streamflow at a nearby relatively unimpacted flow gage, (4) near-term meterological predictions, and (5) operating rules such that a model simulation predicts that desired frequencies will be met. Depending on the spatial extent of application of the calculated IFCs, complicating factors may arise if different locations in the same basin have different hydrologic conditions at

[2] ftp://ftpext.usgs.gov/pub/cr/co/fort.collins/Terrell/txhat/TXHAT.zip

the same time. Consideration may also be given to a distinct hydrologic condition appropriate for extreme droughts.

4. Assignment Period

Straightforward IFCs such as subsistence flows and baseflows consist of continuous flow recommendations that may vary by time period (e.g., monthly or seasonal). Thus, the analyst must decide appropriate time periods for which to assign different values for these recommended flows. More complex, episodic IFCs such as High Flow Pulses (HFPs) and overbank flows occur intermittently and thus must be associated with a recommended frequency of occurrence. The target frequency for these seems to require integer values (i.e., it is seemingly nonsensical to recommend "0.3 High Flow Pulses" during an assignment period). Different analysts may have other ideas, but TPWD staff's opinion is that the assignment period for each of these should be long enough to recommend at least one such event per period. The assignment periods need not be identical for all flow components. However, for all flow components where seasons are desired, the length and monthly assignments to such seasons must be decided.

5. Memory

The analyst must decide if there will be memory, or carry-over, from one assignment period to the next. If there is no memory, then each assignment period begins as a "clean slate" and the under- or over-achievement of episodic flow components in the previous assignment period(s) is moot. Conversely, if memory is included, then some or all of the previous assignment period's under- or over-achievement is carried-over into the current assignment period to either increase or decrease the current assignment period's requirements.

6. IFC Characteristics Delineated

Subsistence flows and baseflows consist of a simple prescribed flow rate that may vary by assignment period. However, HFPs and overbank flows may be delineated using: (1) peak flow, (2) average flow, (3) duration, (4) volume, (5) rise and/or fall rate, (6) frequency, and/or potentially other characteristics. Depending on the analytical tool used, some of these characteristics are used to quantify HFPs and overbank flows. Deviations between the characteristics used to computationally define these IFCs and the characteristics explicitly included in final environmental flow recommendations may result in unintended consequences. For example, if HFPs are quantified in the historical record using a combination of average flow and duration, but recommendations simply specify average flow, HFPs of insufficient duration may result.

7. Subsistence Flows less than 7Q2

Some analytical methods may generate subsistence flows (or even baseflows) that are less than 7Q2. The analyst must decide if/when it is appropriate to recommend flows that may result in the contravention of water quality standards.

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8. Number and Location of Control Points

The analyst must determine the requisite number and locations of control points at which to perform the hydrologic analyses.

9. Spatial Extent of Environmental Flow Recommendations

Environmental flow recommendations may be applied to river reaches instead of simply points. If such is the case, the analyst must decide the spatial extent of each specific flow recommendation. For example, a flow recommendation quantified at a USGS gage may apply upstream to the next USGS gage.

10. Daily Average versus Instantaneous Flow Data

Daily average flow data are readily available[3] and are generally satisfactory for subsistence flow and baseflow determinations. Daily average data may be satisfactory for developing HFPs and overbank flow recommendations, or a method using instantaneous flow data may be desired. IHA solely uses daily flow data. Instantaneous flow data from the USGS (1) are not as thoroughly quality controlled as daily flow data, (2) are not available at all stations, and (3) typically start in the late 1980s[4]. For these reasons, a pre human impact flow record is unlikely to be available and a flow record in excess of 20 years is also unlikely. Typically, the more rare an event is (e.g., a large flood), the more important it is to use instantaneous data and the longer the period of record necessary to accurately quantify the expected frequency of the event. Previously developed flood models may be helpful to quantify flood events.

While the use of daily average flow data is clearly unacceptable for the strict quantification of extreme flood events in flood engineering contexts, the analyst may decide that, with some professional judgment, the use of daily average flow data is acceptable for setting realistic HFP and overbank environmental flow recommendations.

11. Overbank Recommendations

Overbank flows are infrequent, high flow events greater than bankfull that result in the inundation of the adjacent floodplain habitats. Overbank flows are ecologically important and can beneficially restructure the channel and floodplain, recharge groundwater tables, deliver nutrients to riparian vegetation, and connect the channel with floodplain habitats that provide additional food for aquatic organisms. By providing linkages with the stream channel and wetland areas, overbank flows contribute to the creation of waterbird habitat and breeding grounds, fish community diversity, invertebrate colonization, and provide for significant carbon returns to the river. Inclusion of overbank flows as part of a regulatory requirement will be subject to considerations of ecological benefit and issues of liability and the practicality of managing such flows.

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[3] http://waterdata.usgs.gov/tx/nwis/current/?type=flow

[4] http://ida.water.usgs.gov/

12. Ability to Implement Recommendations

Any flow regime concept will be inherently challenging to implement. All other things being equal, the analyst may wish to develop environmental flow recommendations that are easier to implement.

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Decision Points Specific to the HEFR Method

TPWD staff expects these decision points to be fairly specific to the HEFR Method.

1. EFC Parameter Set

The EFC screen in IHA contains seven parameters that control the algorithm that parses a hydrograph into IFCs. Each of these seven must be specified. Default values are provided by IHA, but are not necessarily appropriate for Texas or for a given location in Texas. It is likely that the development of a baseline parameter set for Texas would be desirable, or perhaps one baseline set for each stream classification in Texas (stream classification could be based on TX-HAT, UT research, or other source). It is hoped that this baseline parameter set could be used at multiple locations, recognizing that some locations would require changes from this baseline set due to distinctive variations in flow characteristics or known ecology.

2. Post-IHA Manipulation of IFCs

The EFC function in IHA is flexible, but not infinitely so. The analyst may wish to parse the hydrograph beyond the capabilities of IHA. One example is that IHA may generate long, unbroken, HFPs where, in the judgment of the analyst, more than one discrete pulse is present. This behavior is more common using certain parameter sets than others. Splitting of long HFPs and other manipulations can usually be automated in Excel or other software. If this is done, then all related statistics must be quantified in the accessory software, as IHA statistics will be erroneous.

3. IFC Statistics

Statistics on IFCs may be quantified in IHA if no post-IHA manipulation of IFCs was performed. However, IHA statistics are not necessarily relevant to the needs of the SB3 SAC, BBESTs, and BBASCs. As a result, the analyst may wish to develop custom statistics in accessory software. Required statistics include appropriate measures of all of the IFC characteristics that are delineated in the environmental flow recommendations (see above). For example, the recommended peak flow rate for a HFP during a wet hydrologic condition may be assigned to the 75th percentile of all HFP peak flows. Thus, the capability to quantify the 75th percentile of a dataset would be required.

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