PROGRESS REPORT OF THE BIOLOGY WORKGROUP TO THE SAC

JUNE 5, 2009

Progress Report of the Biology Workgroup to the SAC, June 5, 2009

The Biological Workgroup held its second meeting/teleconference on May 22, 2009. The 13 attendees were:

Kathy Alexander	Kevin Mayes
Dave Bradsby	Ed Oborny
Bryan Cook	Ryan Smith
Gregg Easlley	Joe Trungale
George Guillen	Jim Wiersema
Lynn Hamlin	Kirk Winemuller
Bob Huston	

Other members of the workgroup who could not attend were Norman Johns and Chris Loft.

The meeting was held from 2 p.m. until approximately 4:20 p.m. Much was accomplished and will be shared with the SAC at the June 5 meeting.

Chairman Huston attended and emphasized the need to focus on what recommendations can be made to the BBests within the near term.

Lynn Hamlin prepared the meeting notes contained in Attachment 1.

Attachment 2 is the outline for Biology Workgroup report as modified from my June 5th outline by Kevin Mays and then further modified by Kathy Alexander. Note that we made chapter assignments for the first 5 chapters during the May 22nd meeting.

Lynn Hamlin pointed out to me that we did not assign schedules in the meeting. Subsequent to our meeting, Chairman Huston visited with me about scheduling. Bob indicated that we need to produce a draft of what is feasible to recommend by the end of June. That would allow the SAC members to review and comment and the Workgroup to provide a final draft by the August 2009 SAC meeting.

Attachment 3 is a report on River Types that Ryan Smith presented at the May 22 meeting. This will become a subsection of chapter 2 (see Attachment 2). George Guillen, who has volunteered to write Chapter 4, has indicated to me that he will produce an initial draft by next week. I will distribute that when I receive it.

Attachment 4 is a discussion of the General Hydrologic Methods and HEFR input components where biological data or observations can be applied. The Workgroup spent a considerable time going over each point. The original list was prepared by Kevin Mays. He provided Kathy and I an updated version containing whether the group felt that a particular input could reasonably modified by biological input and whether that input could occur as a preapplication adjustment or as a past implementation input.

Kathy Alexander took Kevin's outline and worked up the version of Attachment 5 presented here. The tables represent draft examples of the types of and basis for biological input to various phases of the HEFR modeling process as they were discussed at our last workgroup meeting. Some or all of these may be applicable in a particular river basin based on data availability. The intent is to show the types of decisions that should have biological input and

why. Also there are some blanks in the table for items we did not discuss. We expect to discuss this as much as possible with the SAC at today's meeting.

Attachment 6 is added for perspective. It is a memo from Kevin Mayes that predates Attachment 4 and provides some idea of the concepts as they are evolving.

Attachment 1

At the first meeting, members were tasked to develop strawman tables or narratives including: 1) the applicability of river type to environmental flow analyses (Ryan), 2) key areas where biology could inform hydrology-based environmental flow analyses (Kevin), 3) the ecological functions of flow components (Kevin), 4) key instream and riparian ecology questions that should be considered during the EF analyses (Joe), and 5) an outline for the final SAC biological overlay document (Jim and Kevin). Let me know if you want copies and I'll forward them.

The candidate list of key areas where biology could inform the pre- and post-processing of HEFR inputs and outputs was reviewed in detail. "Parameterization" is being used to describe adjustments to modeling inputs based on biological information (pre-processing), and "overlay" describes adjustments to the modeling output (post-processing). My note: based on these discussions the SAC guidance document will probably include guidance for parameterization and overlays. Chairman Huston attended and advised the group to focus on what can be done realistically in the period of time allowed; and to focus on parameters where it can be explained how to "get there from here". If we can't answer how to do it then guidance can't be developed. It was suggested the candidate list be divided into two lists to separate parameterization from overlay.

Kevin began revising the candidate list with input from the group and after awhile several members requested a briefing on terminology before finishing the list. They want a primer on HEFR definitions geared toward biologists so they can better understand the terminology and determine how biology can inform the parameter. Specifically, 15 potential HEFR candidates for biological input were listed on the second page including HFP upper threshold, HFP lower threshold, HFP ascending and descending rate of change, etc. Common English definitions would be helpful to better define their biological relevance.

The next meeting will occur in late June. Agenda items and tasks:

1. Primer on terminology
2. MBFIT vs IHA EFC explanation
3. Continue work on tables 1 (ecological functions of flow components) and 2 (key questions on instream and riparian ecology)
4. SAC guidance document chapter 4 draft (George Guillen)
5. SAC guidance document chapter 3 draft (Kathy Alexander with help from Joe Trungale)
6. SAC guidance document chapter 2 draft including the river type narrative (Jim Wiersema)
7. SAC guidance document introduction and chapters 1 and 5 (Kevin Mayes)

At the next SAC in June, Jim and Kevin will provide an update of the biology subgroup's activities and distribute some of the work developed so far.

Attachment 2

Using Biological Information to Run and Refine HEFR

Chapter 1 Introduction (K. Mayes)

- Table 1. Description of ecological roles of instream flow regime components and approaches used to identify recommendations
- Table 3-3 from NAS report (The Science…) which describes biological assessment methods from holistic to specific
- Running HEFR: pre-processing includes geographic scope (Chapter 2) and parameterization and other inputs (Chapter 3)
- Refining HEFR: post-processing includes finding and using biological information to refine or confirm initial HEFR values

Chapter 2 Develop Input for Geographic Scope (J. Wiersema)

- Approach
- River Type discussion (R. Smith)
- Relate to Geographic Scope document

Chapter 3 Develop Input for HEFR settings (K. Alexander, J. Trungale)

- Brief discussion of decision points related to hydrologic methods
- Initial decisions points and inputs such as desired ecological condition (pre- or post-impact conditions or entire period of record), seasonality, hydrographic separation method, episodic event method
- How to parameterize HEFR
    - HEFR, IHA, and MBFIT specific settings

Chapter 4 Information for Biological Overlay (G. Guillen)

- Table 2. Examples and sources of work done to address specific tasks
- Approach for finding and assimilating biological information

Chapter 5 Refining the HEFR Matrix (K. Mayes)

- Magnitudes, frequency, and duration of subsistence and base flows, HFPs, overbank flows, etc.
- Timing: monthly and seasonal adjustments
- Rate of change issues

Chapter 6 Conclusion

Attachment 3

River Type

Classification of river type may be an aide to the BBESTs in developing flow standards, particularly in parameterization of HEFR and development of biological or other overlays. Flow versus ecology relationships often differ from one river ecosystem type to another. Thus, consideration of the structure, function, and other aspects of each river type's ecology helps assure that flow standards developed for each river represent the factors most important to its sound ecological environment.

Benefits of considering river type in development of environmental flows standards include:

- Hydrological, biological, and other types of data may not be available for every river for which the BBEST desires to develop standards. Consideration of river type maximizes the effectiveness of transfer of knowledge (e.g. flow-ecology relationships) from rivers with available data and site-specific flow studies to rivers with no such information.
- It is complex and time consuming to develop recommendations for each control point. Parameterization of HEFR to incorporate ecological considerations may be a more efficient approach than development of site-specific overlays. River type should be considered in such parameterization because the most important flow components and thresholds in alteration of these components may vary across river types.
- The most important HEFR overlays may vary across river type as well. So, river type should be considered in selection of focal species, indicator variables, and other factors for use in biological overlays.
- As discussed in SAC (2009b), consideration of river type helps ensure inclusion of the full diversity of river ecosystem types in determination of the geographic scope of flow standards.

Classifications of river types come in many shapes and sizes. Texas Instream Flows Program (2008) provides one review of classification approaches and makes recommendations on factors to consider in selection of a scheme for Texas rivers. River classifications may be based on hydrology, geomorphology, or ecology or a combination of factors. An important consideration is that if a river classification scheme is to be used to inform biology overlays and/or HEFR parameterization, then it should incorporate at least a coarse consideration of biological and ecological variability. Ultimately, the BBESTs will determine the classification to be used based on their considerations of the most important factors in their basin.

A variety of river classification schemes are available either statewide or in specific areas of the state. Some statewide classifications include:

- Ecoregions (e.g., Griffith et al. 2007) and physiographic provinces (e.g., Johnson 1931)
- Edwards et al. (1999) classification of aquatic communities – not mapped
- Hersh and Maidment (2007) classification of streams integrating hydrography, water quality, climatology, hydrology and hydraulics, geomorphology and physical processes, and biology – mapped statewide at the scale of USGS sub-basins (HUC8's)
- US Geological Survey's Stream Classification Tool for Texas (TxSCT) (Henriksen 2008) is a hydrologic classification based on a unique set of ten, non-redundant, hydrologic indices – available for 297 river gages in TX

- The Nature Conservancy's hierarchical classification of freshwater ecosystems [methodology based on Higgins et al. (2005)] based on river size, physiography/ecoregions, slope, elevation, coarse hydrology, drainage network position, and geological characteristics – mapped statewide in 1:100K NHDPlus, except for portions of the Trans-Pecos (complete summer 2009) (report available December 2009)

In addition, more detailed classifications based on geomorphology exist for some river segments and sub-basins, including the Trinity (REFERENCE) and River Styles (Brierly and Fryirs 2000) classifications for THE Brazos (Phillips 2006) and San Antonio (INSERT REFERENCE).

We recommend that the BBEST's take the following steps in evaluating the utility of river type in development of HEFR parameterization and/or overlays and selecting a classification scheme to provide the context of river types in your basin:

1. Consider variability of river types in your basin (e.g., Central Plains versus Coastal Plain rivers in the Trinity River basin)
2. Determine factors that structure this variability (e.g., is hydrology alone sufficient? Also need ecology? Geomorphology?)
3. Determine, based on SAC (2009b), the river segments for which flow standards will be developed
4. Select a classification that best represents the ecological, hydrological, geomorphological, and other relevant considerations in the selected river segments
5. Select overlays and/or parameterization guidelines for each river type determined to be significant in the river basin

REFERENCES

Brierly, G.J., Fryirs, K., 2000. River styles, a geomorphic approach to catchment characterization: Implications for river rehabilitation in Bega catchment, New South Wales, Australia. Environmental Management 6, 661-679.

Edwards, R.J., G. Longley, R. Moss, J. Ward, R. Matthews, and B. Stewart. 1989. A classification of Texas aquatic communities with special consideration toward the conservation of endangered and threatened taxa. Texas Journal of Science 41:231-240.

Griffith, G., S. Bryce, J. Omernik, and A. Rogers. 2007. Ecoregions of Texas. AS-199 (12/07). Project Report to Texas Commission on Environmental Quality.

Henriksen, J. 2008. Hydroecological Integrity Assessment Process (HIP) for Texas: Stream Classification Tool for Texas (TxSCT). US Geological Survey. To obtain a copy contact Cory Horan.

Hersh, E., and D. Maidment. 2007. An Integrated Stream Classification System for Texas. CRWR Online Report 07-02. Available at http://www.crwr.utexas.edu/online.shtml

Higgins, J.V., M.T. Bryer, M.L. Khoury, and T.W. FitzHugh. 2005. A Freshwater Classification Approach for Biodiversity Conservation Planning. Conservation Biology 19: 432-435.

Johnson, E. 1931. The Natural Regions of Texas. University of Texas Bulletin 3113. Bureau of Business Research. The University of Texas.

Phillips, J. 2006. Field Data Collection In Support of Geomorphic Classification of the lower Brazos And Navasota Rivers. Phase 2 of the project: Geomorphic Context, Constraints, and Change in the lower Brazos and Navasota Rivers, Texas. Final report to the Texas Water Development Board.

SAC (Science Advisory Committee). 2009b. Geographic Scope of Instream Flow Recommendations. Draft Report # SAC-2009-02.

Texas Instream Flows Program. 2008. Texas Instream Flow Studies: Technical Overview. Texas Water Development Board Report 369.

Attachment 4

Workgroup Decisions on Inclusions to HEFR Analysis

General Hydrologic Methods (see Section 4 of hydrologicmethods04202009.pdf for extensive discussion)

1. Number of instream flow regime components (e.g. subsistence, base flow, high flow pulses, and overbanking flows)

   Are there any areas where overbanking flows are not ecologically important?
   Are there any reasons not to have all four?

   YES*

2. Geographic scope of all instream flow recommendations and spatial extent of individual instream flow recommendations (see Geographic Scope doc)

   YES. See document and reference.

3. Hydrologic period of record (e.g., natural, entire, regulated)

   YES

4. Hydrologic/climatic condition (e.g., dry, average, wet)

   YES, statistically parsed. 25th, 50th, 75th

5. Assignment period (e.g., monthly, seasonal, other)

   YES

6. Memory (carry-over from one assignment period to the next?)

   Implementation (post-HEFR)

7. Delineation of flow regime component characteristics (High flow pulses 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 other characteristics.)

   YES, post HEFR overlay

8. Subsistence flows less than published 7Q2 (Is it appropriate to recommend flows that may result in the contravention of water quality standards?)

   Use Zero.
   Water Quality to some extent. – 7Q2 only after use 0 (post-implementation)

***Bold indicates workgroup consensus as of May 22 meeting.**

Post overlay. If issues with subsistence flows, use either no subsistence flow for that month or use average base flow for that month.

9. Number and location of control points (what gages will be used?)

   YES, see geographic scope. Outline Chapter Two.

10. Flow recommendations in the absence of flow gage (e.g., tributaries that do not have a flow gage)

    Constraints level analysis, see geographic scope and Chapter Two.

11. Daily average versus instantaneous flow data (Is daily data sufficient?)
    What situations exist where instantaneous flow data are more important?

    Ask the question – yes or no.

12. Overbank recommendations (important for ecosystems but may raise issues of liability or technically achievable)

    YES. Don't make it an option. Needs to be calculated. Covered in No. 1 above. If you have specific information on overbank flow then use it to define what bankfull is or return interval.
    Depending upon geographic area, it may be a post-process overlay

HEFR (Section 5.8)

1. Hydrographic separation tool (which tool will you use? MBFIT or IHAs Env. Flow Component; see below for more decision points)

   YES, define.

2. Seasonality (how many seasons and length of each season)

   YES

3. Percentiles (wet, dry, and average setup)

   YES

4. Episodic event method (Also see Section 5.7)

   YES

   a. Original HEFR (Percentile-based) Approach
      Which flow characteristic(s) are recommended? Duration, volume, and/or peak (magnitude) flow of high flow pulses (HFP) and overbank events?

b. Alternative Frequency-Based Approach (Section 5.7.2)
    i. Specify magnitude of the HFP and overbank event tiers (levels)
    ii. Specify frequency(ies) of each event tier
    iii. Specify seasonal assignment for each event
    iv. Choose regression method for both volume and duration (log-log or quadratic)
    v. Select significance level for regression prediction intervals (e.g. 68.3 gives one standard deviation assuming normal distribution)

5. Subsistence percentile (What percentile of subsistence flows (extreme low flow output) will be used to determine the subsistence flow recommendations?)

   YES, what level below which would you have ecological problems? Run through HEFR.

6. Multipeaks_multiplier (If used for HFPs and/or overbank flow events, set value of rate of increase - i.e. 1.5 = 50% jump)

   Maybe

****Hydrographic separation using IHA EFC algorithm (see Section 5 of HEFR doc)**

1. HFP upper threshold -

What is the ecological response?

2. HFP lower threshold
3. HFP ascending rate of change
4. HFP descending rate of change
5. small flood recurrence interval
6. large flood recurrence interval
7. extreme low flow threshold (subsistence flow threshold)

****Hydrographic separation using Modified BFI with Threshold Method (MBFIT) algorithm (see Section 5.6.3 of 4202009 version)**

1. N (length of calculation window in days)
2. f (turning point test factor)
3. RF (runoff fraction)
4. HFP upper threshold (same as IHA EFC)
5. HFP lower threshold (same as IHA EFC)
6. extreme low flow threshold (subsistence flow threshold; same as IHA EFC)
7. small flood recurrence interval (same as IHA EFC)
8. large flood recurrence interval (same as IHA EFC)

****We did not complete discussions on these aspects. We hope to have a presentation later in June to the workgroup on these issues. See Notes (Attachment 1).**

Attachment 5

Table 1. Pre-Processing Decision Points

Pre-Processing Decision Points	**Biological Significance**
Period of Record	Define Desired Ecological Conditions What are we trying to protect or restore? What is the base period? What are the reference conditions?
Number of Instream Flow Components	Are there any areas where overbanking flows are not ecologically important or could pose as a flood hazard to inhabitants living in the flood plain ? Are there any reasons not to have all four flow components?
Daily average versus instantaneous flow data	Is daily data sufficient? What situations exist (for example species life history concerns) where instantaneous flow data are more important? For example, diurnal feeding patterns and/or migration triggers may be triggered at specific flows within a day……or night?
Hydrographic Separation Tool	Identify the ecologically and biologically important components of the flow regime. For example, do small runoff events provide any of the ecological benefits associated with high flow pulses without necessarily meeting the criteria of a high flow pulse? Is the ecological role of leading and trailing limbs more akin to base flows or high flow pulses? Do very high flows, even if sustained for a period, serve the habitat functions of base flows? Note that high flows and base flows can also serve different habitat functions.
Episodic Event Method	Which flow characteristic(s) should be considered? Duration, volume, and/or peak (magnitude) flow of high flow pulses (HFP) and overbank events? Which method best characterizes the flows needed to maintain the ecological functions of a river system?

Table 2. Biological Input to the IHA Hydrographic Characterization

Decision Points for IHA	**Biological Significance**
Percentiles (wet, dry, and average setup)	Community Diversity, Habitat Quality and Quantity
Subsistence percentile	Is there a flow level below which there would be ecological problems associated with water quality or significant habitat reduction? Consider Water Quality Concerns, Life Cycle Cues, Provision of Refuge Habitat
HFP upper threshold and lower threshold	Maintain important physical features and riparian connectivity, Provide migration and spawning cues for fish
HFP ascending and descending rate of change	Rise rates that are too rapid may wash aquatic organisms downstream before they can find shelter along the river margins. Fall rates that are too rapid may lead to stranding of aquatic organisms in shallow areas.
Small and large flood recurrence interval	Maintain important physical features and connectivity to riparian areas. Provide water and nutrients to floodplain depression pools or backwater sloughs used as spawning areas.
Extreme low flow threshold (subsistence flow threshold)	Is there a flow level below which there would be ecological problems? Water Quality Concerns, Life Cycle Cues, Provision of Refuge Habitat

Table 3. Biological Input to the MBFIT Hydrographic Characterization

Decision Points for MBFIT	**Biological Significance**
N (length of calculation window in days) f (turning point test factor) RF (runoff fraction)	
HFP upper threshold (same as IHA EFC) HFP lower threshold (same as IHA EFC)	Maintain important physical features and connectivity, Provide migration and spawning cues for fish
Extreme low flow threshold	Is there a flow level below which there would be ecological problems associated with water quality or significant habitat reduction? Consider Water Quality Concerns, Life Cycle Cues, Provision of Refuge Habitat

Table 4. Biological Input to HEFR

Decision Points for HEFR	Biological Significance
Subsistence Flows Threshhold Percentile	Is there a flow level below which there would be ecological problems? Water Quality Concerns, Life Cycle Cues, Provision of Refuge Habitat
Multipeaks-Multiplier	Are there ecological justifications to recommend a very long pulse, or should the long pulses be disaggregated into multiple pulses?
Hydrologic Conditions (wet dry, average)	From an ecological perspective are all three conditions needed? (see Colorado IF study) If all three are needed is there specific biological information that should guide the choice of the percentiles?
Water Quality Protection Flow	Can the Subsistence flows be less than published 7Q2? Is it appropriate to recommend flows that may result in the contravention of water quality standards? Is there data reflecting healthy communities at flows below 7Q2?
Seasonality	Provide migration and spawning cues for fish and seasonal flux in water quality (temp, DO). and invertebrates (e.g., mussels, prawns), Examine life cycle length and milestones (reproduction, egg and larval development/diapause, growth, maturity, etc.) of key species and/or assemblages for seasonal alignments, Riparian connectivity may also be more important at certain times of the year.

Attachment 6

From: Kevin Mayes [mailto:Kevin.Mayes@tpwd.state.tx.us]
Sent: Friday, May 15, 2009 4:51 PM
To: Jim Wiersema; Bonner, Timothy H; bryan.cook@lcra.org; Christopher Loft; David Bradsby; Edmund Oborny; George J. Guillen; Gregg Easley; Joe Trungale; kalexand@tceq.state.tx.us; Kirk Winemiller; Lynne Hamlin; Norman Johns; Ryan Smith
Cc: Robert Huston; John Botros; Clint Robertson; Cindy Loeffler; Dan Opdyke; Kevin Mayes
Subject: RE: Environmental Flows Biological Workgroup to assist the Science Advisory Committee (SAC)

Attached is a list of decision points for applying HEFR to develop initial instream flow regime values; these are compiled from the HEFR document of 04-20-2009. I put a brief annotation where I could. It would really help if each of you reviewed (again) the HEFR doc in light of this task (attached). We can talk about each of these in terms of biological input needed and why it's important. It may be that we decide that some or a lot of these decision points are **not** ripe for biological input.

I have also attached a fuller table two; still some holes we need to fill and discuss. This will be an important table since it will identify specific examples that will help teams drill in on important tasks. Please take a look and help populate the fields.

Finally at the risk of raising a few of Jim's hairs, I will take a stab at a different version of the outline incorporating a few more pieces of the puzzle including his outline.

Chapter 1 Introduction
- Table One etc (under development; need more input please)
- Maybe Table 3-3 from NAS report (The Science…)which describes biological assessment methods from holistic to specific.

Chapter 2 Develop Input for Geographic Scope
- Jim's outline (I through IV) describes approach
- Ryan's River Type writeup here or in ch 4
- Relate to Geographic Scope document

Chapter 3 Develop Input for HEFR settings
- discussion of decision points
- start with whole list and drill down on biologically relevant points

Chapter 4 Develop Information for Biological Overlay
- Table 2 etc. (under development) will provide examples and sources of work done to address specific tasks
- Ryan's River Type writeup ?
- Scope of Work (SNBBEST doc) describes approach; make it our own and elaborate

Chapter 5 Integration (not a simple matter and may better fit in another SAC document that deals with the broader issue of multidisciplinary integration)

Chapter 6 Conclusion

Any input appreciated and thanks again for taking time to contribute to the workgroup.

***sitename*_HydrographicSeparation_*date*.xls**

This document contains information to aid analysts in the application of a spreadsheet program to perform a hydrographic separation (classification). This hydrographic classification is a preprocessing step to the application of the HEFR program. The classification methods in the spreadsheet assign a code to each day in the record to classify each day as an extreme low flow, base flow, high flow pulse, small flood or large flood. There are two methods included in the spreadsheet. The first, IHA-EFC, implements the method used in the IHA software program. (The Nature Conservancy, 2007). The second method, MBFIT, is a modification of the Baseflow Index (BFI) approach developed by the Institute of Hydrology (Institute of Hydrology, 1980a and 1980b). The primary output from this spreadsheet is the column labeled Code3 and is calculated for both IHA-EFC and MBFIT. The values from Code3, for the method determined by the analyst as the most appropriate, should be copied and pasted into column C of the IHA EFC output sheet "daily efcs" in Excel. Other IHA output sheets in Excel (if present) should be deleted. Column D of "daily efcs" must also be updated; this is most easily accomplished using nested IF statements to associate the text values in column D with the numeric codes in column C. The HERF program should then be executed at that time.

Conventions

To save computer time and space the results of many of the calculations in this spreadsheet have been converted to values using the Copy and PasteSpecial->values option in Excel. These values will need to be recalculated when updating for a new gauge or when the calibration parameters have been modified. The macro UpdateCalcs can be used to update these calculations. It takes a minute or two run.

Yellow cells are parameters that the analyst can modify to calibrate the classification.

Grey cells have formulas which should not be edited.

Turquoise cells should be edited by the analyst but are used for display and don't effect the primary calculations.

Steps to update for another site. (Save often)

1. Make a working copy of the spreadsheet and save a clean version.

2. Determine number of rows needed for period of record being analyzed. Enter the starting and ending dates that will be analyzed in cells A3 (start date) and B3 (end date) to have the program calculate the last row in the daily (C3) and annual (D3) arrays.

3. Size the spreadsheet as needed. If the new site contains fewer rows than the Evadale site (Evadale is the example site used for the HEFR documentation), delete all rows below the last row. If the new site contains more rows than the Evadale site, insert rows so that the last row is what is determined in cell C3. Be sure to insert rows between existing rows rather than dragging the formula down from the existing last row. If rows are properly inserted, all of the formulas and charts will update correctly, if not formulas and chart titles to be corrected manually. Similarly, cells will need to be inserted or deleted from columns AF and AG to properly size the columns that contain annual maximums.

4. Copy date and flow data (presumably downloaded from the USGS) into cells A43:B43.

5. Update the gage name in cell A1.

6. Update Calculations using the UpdateCals macro.

7. View Graphs – There are three graphs to the far right of the worksheet, scales will likely need adjusting. Graph 1 shows the 25th, 50th, and 75th low flow (i.e., base flow) percentiles for the two alternative classification approaches. Graph 2 shows the low/high classification (code1) from the IHA-HEFR method. Graph 3 shows the low/high classification (code1) from the MBFIT method. UpdateXaxis macro can be used to view the results in Graphs 2 and 3 stepping through time.

Macros

There are two macros included in the file used to update calculations and review outputs.

UpdateCals macro is used after making changes to the various base flow classification parameters (cells colored Yellow). The macro copies down formulas from AG3 to the row number calculated in cell D3, C45:S45 to the row number calculated in cell C3 and from D10:I10 to Row 21. It is only necessary to save computer time and space. The cells in Grey contain formulas that should not be edited.

UpdateXaxis macro is intended to aid in reviewing the results in Graphs 2 and 3. It is used to step through time to view the results of the separation. There are several options (cells colored Turquoise) in cells Q32, Q33, R32, R34 that give the user the ability set the period of record to display.

Algorithms

The following sections describe some of the more complex calculations in the spreadsheet, specifically the calculation of Code0 for the IHA-EFC algorithm and the Code1 for MBFIT. Code3 (column H for the IHA-EFC method and column O for the MBFIT method) is the final baseflow code that will be used in subsequent HERF steps. Once the user is satisfied with the parameterization of one of these methods, the Code3 values can be copied into the code column in the "daily efcs" page.

Code 0 – (IHA-EFC only)

Implementation of the algorithm described in the IHA users manual (p 15 Version 7 March 2007) to classify flow as either (-1) low flow, (-2) ascending limb high flow or (-3) descending limb high flow.

Code0=IF(C43=-1,IF(B44<=$G$33,-1,IF(OR(B44>$G$32,(B44-B43)/B43>$F$26),-2,-1)),IF(C43=-2,IF(B44<=$G$33,-1,IF((B44-B43)/B43*(-1)>$F$27,-3,-2)),IF(B44<=$G$33,-1,IF(B44>$G$32,-3,IF((B44-B43)/B43>$F$26,-2,IF(((B44-B43)/B43)*(-1)<$F$27,-1,-3))))))

If the previous days flow was low flow

=IF(C43=-1,

Then if today's flow is less than the low flow threshold, today is low flow

IF(B44<=$G$33,-1,

Otherwise if today's flow is greater than the upper threshold OR the rate of change is greater than the rising threshold then today is rising otherwise it is still low flow

IF(OR(B44>$G$32,(B44-B43)/B43>$F$26),-2,-1)),

If the previous days flow was an ascending limb

IF(C43=-2,

Then if today's flow is less than the low flow threshold, today is low flow

IF(B44<=$G$33,-1,

If the rate of change is greater than the declining rate then today is descending otherwise it is still ascending. (This is a bit counter-intuitive. If you are on an ascending limb and yesterdays flow was 100 cfs and today is 99, today is still considered part of the ascending limb since the flow has not started falling fast enough to be considered declining)

IF((B44-B43)/B43*(-1)>$F$27,-3,-2)),

If the previous days flow was a descending limb

Then if today's flow is less than the low flow threshold, today is low flow

IF(B44<=$G$33,-1,

If today's flow is still greater than the upper threshold it is still descending

IF(B44>$G$32,-3,

If the rate of change is greater than the rising rate then today goes back to rising

IF((B44-B43)/B43>$F$26,-2,

If the rate of change is less than the declining rate then today is low other wise it is still descending

IF(((B44-B43)/B43)*(-1)<$F$27,-1,-3))))))

Code 1

Classifies each day as (1) low flow or (2) high flow.

Code 1 calculated for IHA simply so that it can be compared with the MBFIT method.

Code1 is used to produce the results in Graphs 2 and 3.

Code 1 for the MBFIT option is fairly complex and is discussed in detail below.

First find the local minimum within an N day window.

This local minimum can be considered the base flow portion of the flow on a given day.

Min=MIN(OFFSET(B44,MAX(-(ROW()-ROW(I$42)-1),-(($K$26-1)/2)),0,MIN(ROW()-ROW(I$42)+(($K$26-1)/2),$K$26),1))

This formula is complicated because of the start up days. The goal is to find the minimum flow in an N day window. So if N = 9, you need to look at the previous 4 days and the subsequent 4 days around the current day. For the first 4

days in the record there are not 4 previous days to access, therefore the code is written to only look back as many days as there are (on the third day there would be two previous days)

Second, find turning points.:

Given three adjacent N-day minimum flows, Q_0, Q_1, and Q_2:

Q_1 is a turning point IF:

$Q_1 * f <= Q_0$ and $Q_1 * f <= Q_2$

where f is a turning-point test factor that must be greater than 0 and should be less than 1.

If percent of the current days flow is less than the local minimum for the flow N days ago and N days hence then today is a turning point, (and may be a base flow day). (Column J)

TP=IF(ROW()-ROW(J$42)-1<$K$26,"",IF(AND($K$27*I44<OFFSET(I44,-$K$26,0,1,1),$K$27*I44<OFFSET(I44,+$K$26,0,1,1)),I44,""))

Third determine if the day is base or pulse flow dominated.

If the current day is a turning point, then determine whether the total flow on that day is base or pulse flow dominated. The test parameter is runoff fraction. If the portion of the flow that is considered runoff or pulse flow is greater than the runoff fraction of the base flow portion, then the day is classified as a pulse day otherwise it is a base flow day.

For example if the flow on a given day is 110 cfs and the turning point value (= baseflow portion of the flow on a given day = minimum within N day window) is 100, should the day be categorized as a baseflow day or a pulse flow day? If the runoff fraction is 0.20 then the runoff fraction times the baseflow portion of the flow equals 20, since the pulse flow portion of the flow on this day is 10cfs {abs(baseflow portion-total flow)} Perhaps put more simply this days is a baseflow dominated day because the portion of the flow that is pulse flow (the 10 cfs) is not a significant enough portion to say the day is pulse flow dominated. Increasing the runoff fraction raises the standard on what will be considered a pulse dominated day and will result in more days being classified as base flow dominated.

The part of the code that does not include the magnitude thresholds is

IF(J44="",2,IF(ABS(J44-B44)>$K$28*J44,2,1) (part of the equation in column J)

Forth apply the magnitude thresholds which automatically classify high and low flows.

The full calculation of Code1 for the modified BFI includes magnitude thresholds (L32 and L33) however if user inputs 100 and 0 for the upper and lower percentiles, the program returns the period of record maximum and minimum flow which means they have no effect on the classification, the separation becomes a pure Modified BFI without any threshold considerations.

Code1=IF(B44>$L$32,2,IF(B44<$L$33,1,IF(J44="",2,IF(ABS(J44-B44)>$K$28*J44,2,1))))

More information on the BFI method can be found at http://www.usbr.gov/pmts/hydraulics_lab/twahl/bfi/

Code 2

Classifies each day as (0) extreme low flow, (1) low flow, (2) high flow pulse, (3) small flood or (4) large flood.

Code 3

Classifies each day based on the event that it is part of. So although the flow on a particular day may be less than the small flood threshold, if that storm event eventually exceeds the small flood threshold, then all the days in that event are classified as small flood days. This code is the primary output from the spreadsheet and should be copied and pasted into IHA code column on the “daily efcs” sheet in HEFR.

Checks

Can be deleted.

References

Institute of Hydrology, 1980a.: *Low-flow studies*. Report No. 1, I of H, Wallingford, Oxon, UK.

Institute of Hydrology, 1980b.: *Low-flow studies*. Report No. 3. I of H, Wallingford, Oxon, UK.

The Nature Conservancy, 2007: Indicators of Hydrologic Alteration Version 7 User's Manual. Arlington, VA: The Nature Conservancy.

General Hydrologic Methods (see Section 4 of hydrologicmethods04202009.pdf for extensive discussion)

13. Number of instream flow regime components (e.g. subsistence, base flow, high flow pulses, and overbanking flows)
14. Geographic scope of all instream flow recommendations and spatial extent of individual instream flow recommendations (see Geographic Scope doc)
15. Hydrologic period of record (e.g., natural, entire, regulated)
16. Hydrologic/climatic condition (e.g., dry, average, wet)
17. Assignment period (e.g., monthly, seasonal, other)
18. Memory (carry-over from one assignment period to the next?)
19. Delineation of flow regime component characteristics (High flow pulses 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 other characteristics.)
20. Subsistence flows less than 7Q2 (Is it appropriate to recommend flows that may result in the contravention of water quality standards?)
21. Number and location of control points (what gages will be used?)
22. Flow recommendations in the absence of flow gage (e.g., tributaries that do not have a flow gage)
23. Daily average versus instantaneous flow data (Is daily data sufficient?)
24. Overbank recommendations (important for ecosystems but may raise issues of liability or technically achievable)

HEFR (Section 5.8)

7. Hydrographic separation tool (which tool will you use? MBFIT or IHAs Env. Flow Component; see below for more decision points)
8. Seasonality (how many seasons and length of each season)
9. Percentiles (wet, dry, and average setup)
10. Episodic event method (Also see Section 5.7)
    a. Original HEFR (Percentile-based) Approach
       Which flow characteristic(s) are recommended? Duration, volume, and/or peak (magnitude) flow of high flow pulses (HFP) and overbank events?
    b. Alternative Frequency-Based Approach (Section 5.7.2)
       i. Specify magnitude of the HFP and overbank event tiers (levels)
       ii. Specify frequency(ies) of each event tier
       iii. Specify seasonal assignment for each event
       iv. Choose regression method for both volume and duration (log-log or quadratic)
       v. Select significance level for regression prediction intervals (e.g. 68.3 gives one standard deviation assuming normal distribution)
11. Subsistence percentile (What percentile of subsistence flows (extreme low flow output) will be used to determine the subsistence flow recommendations?)
12. Multipeaks_multiplier (If used for HFPs and/or overbank flow events, set value of rate of increase - i.e. 1.5 = 50% jump)

Hydrographic separation using IHA EFC algorithm (see Section 5 of HEFR doc)

1. HFP upper threshold
2. HFP lower threshold
3. HFP ascending rate of change
4. HFP descending rate of change
5. small flood recurrence interval
6. large flood recurrence interval
7. extreme low flow threshold (subsistence flow threshold)

Hydrographic separation using Modified BFI with Threshold Method (MBFIT) algorithm (see Section 5.6.3 of 4202009 version)

1. N (length of calculation window in days)
2. f (turning point test factor)
3. RF (runoff fraction)
4. HFP upper threshold (same as IHA EFC)
5. HFP lower threshold (same as IHA EFC)
6. extreme low flow threshold (subsistence flow threshold; same as IHA EFC)
7. small flood recurrence interval (same as IHA EFC)
8. large flood recurrence interval (same as IHA EFC)

Table 1. Ecological functions performed by instream flow regime components (adapted from Richter et al. 2006 and TIFP 2008)

Flow Regime Component	Ecological Role	Approaches (level of effort)
Subsistence flows	Maintain water quality standards, i.e. suitable water temperatures, dissolved oxygen levels, and other parameters of water chemistry	7Q2 or other flow that protects water quality (low); existing water quality model (moderate); new water quality model (high)
	Maintain critical aquatic habitats (e.g., riffles) and longitudinal connectivity	visual observation (low); cross-section ratings (moderate); habitat-based model (high)
	Concentrates biota into limited space leading to increased predation, mortality, and other stressors	literature review of life histories (low); biological sampling (moderate); bioenergetics modeling (high)
	May shift community structure including changes in non-natives, lotic-adapted, and intolerant biota	assemblage data analysis (low); biological sampling (moderate); population dynamics modeling (high)
Base flows	Provide suitable habitat for aquatic organisms	standard-setting e.g., Lyons Method (low); cross-section ratings (moderate); habitat-based modeling (high)
	Maintain diversity of habitats	habitat mapping (moderate); habitat-based modeling (high)
	Support growth, survival, and reproduction of aquatic organisms	review available life history information (low); assemblage sampling (moderate);
	Maintain water table levels in floodplain and soil moisture for plants	
	Provide connectivity along channel corridor	
High flow pulses	Shape physical habitat of river channel including pools, runs and riffles	
	Flush out silt and fine particulate materials	
	Redistribute some substrates (sand, gravel, cobble)	
	Prevent riparian vegetation from encroaching into channel	
	Restore normal water quality conditions after prolonged subsistence or low base flows	7Q2 or other flow that protects water quality (low); existing water quality model (moderate); new water quality model (high)
	Provide spawning cues for some species	review available life history information

	Provide connectivity to oxbows and other wetlands	review available life history information (low); assemblage sampling (moderate); hydraulic modeling (high)
	Provide migration and spawning cues for some species	review available life history information
	Enable fish and other biota to feed and spawn on floodplain	review available life history information
	Provide nursery area for juvenile fish and other biota	review available life history information
	Facilitate exchange of nutrients, sediments, organics and woody debris	
Overbank flows	Recharge floodplain water table	
	Maintain balance and diversity in floodplain forests	
	Drive lateral movement of river channel forming new habitats (secondary channels, oxbow lakes)	
	Shape physical habitats of channel and floodplain	
	Redistribute coarse substrates (gravel, cobble, boulder) in channel	
	Scour rooted aquatic vegetation from the channel	
	Purge invasive species from aquatic and riparian communities	

Table 2 Tasks

Instream Ecology	Example Source	Description
Summarize biological data that have been collected in the study area. Who collected these data, over what time frame, how often, and by what methodology?	University of Texas at Austin, Texas Natural History Collections Fishes of Texas Project database (http://www.utexas.edu/tmm/tnhc/fish/index.html)	Georeferenced database of historical fish collections primarily from museum records
Has the abundance or distribution of certain species changed over time? Are these changes thought to be linked to changes in river flow? Are data available to document these trends and linkages?	Bonner, T. and D. Runyan. 2007. Fish Assemblage Changes in Three Western Gulf Slope Drainages. Report to TWDB, Austin, TX.	Reports developed as part of the Texas Instream Flow Program include analysis of temporal trends in species relative abundance.
	Anderson, A.A., C. Hubbs, K.O. Winemiller, and R.J. Edwards. 1995. Texas freshwater fish assemblages following three decades of environmental change. *Southwestern Naturalist* 40(3):314-321.	Analysis of long-term database that reveals general patterns of fish faunal change in Texas river basins.
What species (fishes, reptiles, birds, mammals, invertebrates, aquatic plants) are of greatest concern from either ecological, socioeconomic or recreational standpoints?	Texas Parks and Wildlife website on Rare, Threatened, and Endangered Species (http://www.tpwd.state.tx.us/huntwild/wild/species/endang/index.phtml)	search T&E species by county
What is known about the linkages between flow variations and life histories of key/indicator species? What times of year are most critical for these species, their life stages, and species assemblages?	Winemiller, K.O., A. Chin, S.E. Davis, D.L. Roelke, L.M. Romero, B. Wilcox. 2005. Summary Report Supporting the Development of Flow Recommendations for the Stretch of Big Cypress Creek below Lake O' the Pines Dam. Report to The Nature Conservancy/Caddo Lake Institute. p 65-91.	Caddo report developed a list of indicator species based on their dependency on flowing water. Report also includes annotated bibliography including historical collection, available life history information, species lists with supplemental information.

	Texas Freshwater Fishes Website (http://www.bio.txstate.edu/~tbonner/txfishes/index.htm)	Texas State web site include life history and habitat association data for species by basin.
Can the flow needs of certain indicator species be used to represent the flow needs of assemblages of organisms (e.g., fish, crustacean or mussel assemblages)?	USACE. 1994. Red River Waterway Project, Shreveport, LA, to Daingerfield, TX, Reach, Reevaluation Study In-Progress Review: Appendix 6. Aquatic Resources.	Dominate species within habitat guilds (based on preferred velocities and spawning substrate) selected as indicator species.
If the instream flow regime has been altered by human influences, are necessary flow conditions still properly sequenced to enable successful life cycle completion for indicator species?		
Which habitats are most limiting, and what is the importance of flow regime components for developing and maintaining these habitats?	BIO-WEST. 2009. Instream Flow Guidelines - Relationships to Aquatic Habitat and State Threatened Species: Blue Sucker.	Hydrodynamic models used to predict habitat flow relationships
	Mosier, D. T., and R.T. Ray. 1992. Instream flow for the lower Colorado River: reconciling beneficial uses with the ecological requirements of the native aquatic community. Lower Colorado River Authority.	Instream flow assessment
Are aquatic floodplain habitats critical for maintaining fish populations in rivers?	Winemiller, K., F. Gelwick, T. Bonner, S. Zeug, and C. Williams. 2004. Response of Oxbow Lake Biota to Hydrologic Exchanges with the Brazos River Channel	Approach for assessing connectivity.
Is the aquatic ecosystem dependent upon material subsidies (e.g., detritus, nutrients) that are brought into the river from the floodplain during floods?		
What specific instream flows are required by certain species during particular periods (e.g., seasonal) in order to facilitate movements within the riverscape?		

Riparian Ecology	Example Source	Description
What is the extent and distribution of riparian areas in the study area?	To be determined for Texas - good start with the Texas Parks & Wildlife/Nature Serve System (TPWD GIS Lab, in progress)	vegetation classification database
	NRC (National Research Council), 2002, Riparian areas-functions and strategies for management: Washington, D.C., National Academy Press, www.nap.edu/books/0309082951/html	
What is known about relationships between river flows, alluvial water table levels, floodplain inundation patterns, and the influence of these hydrologic conditions on riparian areas?	Busch, D.E. and Scott, M.L., 1995, Western riparian ecosystems, in LaRoe, E.T., Farris, G.S., Puckett, E.E., Doran. P.D., and Mac, M.J., eds., Our living resources- a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems: U.S. Department of the Interior, National Biological Service, p. 286-290.	
	Tabacchi, E., 2005, Vegetation patterns and ecological dynamics along narrow riparian zones, in Petts, G., and Kennedy, R., eds., Emerging concepts for integrating human and environmental water needs in river basin management, ERDC/EL TR-05-13: U.S. Army Corps of Engineers, p. 66-71, el.erdc.usace.army.mil/elpubs/pdf/trel05-13.pdf	
How does the riparian corridor depend upon physical habitat conditions that are shaped by river flows? Is lateral channel migration or bar formation important in forming these physical habitats?	National Research Council. 2002. Riparian areas-functions and strategies for management: Washington, D.C., National Academy Press.	