

NUTRIENT AND WATER QUALITY OVERLAY ON HYDROLOGY-BASED
INSTREAM FLOW RECOMMENDATIONS
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BACKGROUND

SB 3 directed the development of environmental flow recommendations for Texas waters through a science-based determination and Stakeholder process, followed by TCEQ rulemaking. Environmental flow regimes are defined as schedules of flow quantities that: reflect seasonal and yearly fluctuations for specific areas of watersheds, support a sound ecological environment, and maintain the productivity, extent, and persistence of key aquatic habitats. A working draft document (Report # SAC-2009-01) provides an overview of how hydrologic data might be used in Hydrology-Based Environmental Flow Regime (HEFR) analysis pursuant to the requirements of SB 3. This draft describes one piece of the collaborative process envisioned by SB 3 for the identification of flows to maintain a sound ecological environment in rivers and streams. The document notes that other disciplines such as biology, geomorphology, and water quality, also warrant specific attention to ensure that instream flow recommendations are based on the broadest set of information available.

Water quality is addressed in this document. Water quality considerations including dissolved solids, nutrients, toxics, indicator bacteria, temperature, pH, dissolved oxygen, and other parameters may play a role in the determination of an environmental flow regime for a river and stream. For rivers and streams it is assumed that under natural conditions, which may have existed prior to human impacts, water quality supports the desired sound ecological environment. It is also recognized that natural conditions contain a substantial range in all of the dimensions of water quality in response to hydrologic, seasonal and weather variations, and that natural conditions include a full range of undesirable outcomes—flood damage, habitat loss and fish kills in dry periods, etc.

Management and protection of water quality has been a primary mission of the TCEQ and predecessor agencies in Texas since well before the federal Clean Water Act in 1972. The TCEQ has established a set of Surface Water Quality Standards (TCEQ, 2000) that include both general requirements and those that are specific to water quality segments specified for each major river basin. As such, the Standards attempt to account for climate and hydrologic variations for state waters. The evolution of water quality standards has centered on control of wastewater discharges, partly through the process of developing and enforcing wastewater discharge permits. In cases where the Texas Standards are not attained through normal wastewater permitting, special studies such as Total Maximum Daily Load or Waste Load Evaluations are required. The Standards are also periodically updated to better reflect natural conditions as our data and knowledge are improved, and a revision process is underway at this time.

Taking water quality considerations into account in the determination of environmental flows has been addressed in some specific cases. For example, flows released from an upstream reservoir for environmental purposes during the summer may have relatively low dissolved oxygen (DO) content. A response has been to require aeration of these flows. For this analysis, water quality considerations are addressed from two directions. The first is the traditional approach--to insure that an alteration of hydrology does not produce an adverse water quality effect. The other is to consider how a desire to improve some dimension of water quality might factor into the selection of an environmental flow regime. The first approach focuses on protecting water quality and can be considered to be playing defense while the second is taking water quality on the offense.

WATER QUALITY OVERLAY

From the perspective of protecting water quality from the effect of changes from an analysis based on hydrology alone, there would be several steps. The first

would be a review of the water quality attainment status of the stream (<http://www.tceq.state.tx.us/implementation/water/tmdl/index.html>). A second step would be to determine if the inflow regime involved a change in the flow distribution, timing or quality characteristics. If the HEFR analysis is used only to specify a flow regime needed to maintain an existing system and did not require a change in flows, then there may not be a need to address water quality protection. On the other hand, if the flow regime specified with HEFR differed from the existing flow regime, and as a result water quality might be expected to change, the water quality effect would need to be addressed. For example, if a pre-impoundment flow record is used to define an inflow regime for a stream that today has significant upstream impoundments, there is a reason to require consideration of water quality effects.

A limitation that must be recognized is that our water quality standards were developed largely in the context of addressing pollution due to wastewater discharges, and thus tend to be oriented to providing protection under critical low flow conditions e.g. providing minimum dissolved oxygen (DO) at the 7Q2 flow. Aspects such as providing pulses of higher flow or modifying the low flow distribution for ecological reasons have not been a water quality focus up to now. It would appear that addressing the water quality dimension of providing environmental flows that are based initially on hydrology alone may require a several step process. The first step will be developing the functional relation between flow and water quality parameters that are likely to be relevant to the location.

DEVELOPING FLOW-QUALITY RELATIONSHIPS

The first step in developing an understanding of how the relevant water quality parameters are affected by different flow conditions can be as simple as developing plots. Some examples are provided for Total Nitrogen in Figures 1 and 2. Similar plots could be developed for a range of water quality parameters

such as dissolved solids, toxics, indicator bacteria, temperature, etc. If sufficient data were not available at the site being studied, data from nearby similar locations if available might be employed to develop these relationships.

A very strong relation between flow and total nitrogen content is shown in Figure 1 while Figure 2 shows a weak relation typical of a less modified watershed. (need to add a figure for a natural watershed that illustrates increasing concentration with flow)

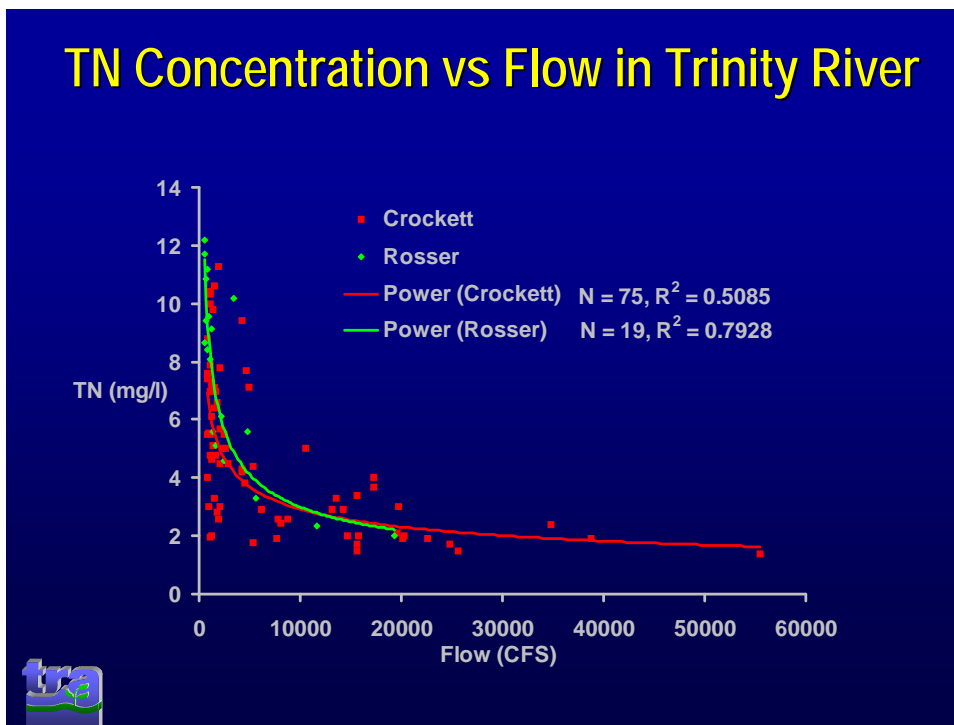


Figure 1 Total N and Flow on the Trinity River

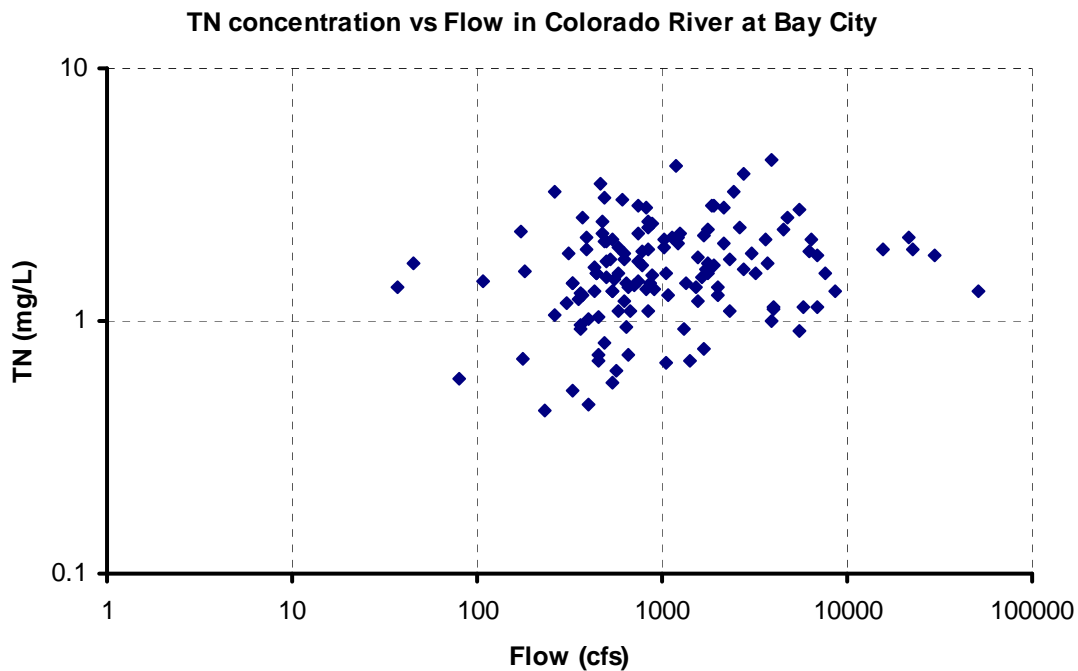


Figure 2 Colorado River at Bay City Total N versus Flow

As part of this process it may prove worthwhile to investigate the relationship between various ecological processes and flow. Doyle et al. (2005) provides an overview of work on how different flow ranges affect different ecological aspects, drawing on the relation with sediment transport, where moderate flow pulses (1 to 5 year recurrence interval) tend to be the most effective in sediment transport. Doyle et al. investigated four ecological processes: sediment and nutrient transport, habitat regulator, process modulator and ecological disturbance, and found varying types of relations with flow. For example, with sediment and nutrient transport, there would be a difference in the effective flow range depending on the functional relation. With particulate matter (sediment and part of the nutrient pool) there is often an increase in concentration with flow so that the most effective flow for transport will be in the moderate pulse range. But in streams such as the Trinity River shown in Figure 1, where the total N concentrations are highest at the lower flows, which also tend to have the highest frequency of occurrence, the most effective discharge for total N will tend to be shaded towards the base flows. In the Colorado River example in Figure 2, where the overall concentrations are lower and appear to be essentially constant across a range of flows, the most effective discharge would be higher than the base flows reflecting the greater capacity of higher flows.

From the perspective of habitat regulation, Doyle et al. (2005) found that flow was often a key factor in determining the amount of habitat in a river but that relations could be very different for different species. In relation to process modulation and disturbance, the most effective flow range can be defined for a specific ecological response function. The problem recognized is that there are many different process and disturbance mechanisms to consider. Developing the target or most ecologically important flow range to emphasize depends on defining the ecological response desired.

ASSESSING QUALITY EFFECTS

With a suitable understanding of how flow and quality responses developed, the next component would be to assess the water quality effects of the proposed hydrology-based environmental flow recommendations on the water quality parameters likely to be affected by changes in flow, and determine what type of response or adjustments might be needed. The assessment should include the site (flow gauging station) where the environmental flow recommendations were developed as well as downstream areas. The downstream assessment should consider changes in the distribution of water quality parameters and changes in the longer term loadings of somewhat conservative parameters such as solids, nutrients and toxics. This loading dimension could be important if reservoirs were located downstream of the point under consideration, as they tend to retain and accumulate materials contributed in a range of flows.

Determining the appropriate response to the proposed change in flow distribution will pose some challenges. One aspect would be to insure that the flow changes would not result in non-attainment of some aspect of the existing water quality standards. But simply relying on the standards may not be sufficient. It is entirely possible that there could be a significant water quality effect that would not produce a situation where the standards were not attained, but could still be

considered adverse. In addition to protecting from adverse effects, there may be situations where it is possible to define a change in a flow regime based on water quality improvements considered desirable. In this case the water quality overlay process could act to support or reinforce the broad ecological goals of the environmental flow process.

It should be recognized that because this type of water quality assessment has not been routinely produced, procedures and details will need to be developed and will tend to be somewhat site-specific. In some cases we may be able to quantify a difference in a nutrient or trace metal input in response to the change in flows but have no quantitative means to assess the ecological significance of the change. This type of situation should be viewed as a step in the evolution of the process of developing sound environmental flow recommendations.

REFERENCES

Doyle, M., E. Stanley, D. Strayer, R. Jacobson and J. Schmidt. 2005. Effective discharge analysis of ecological processes in streams. *Water Resources Research*, Vol 41, W11411, doi:10.1029

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