EXAMINATION OF ENVIRONMENTAL HIGH PULSE FLOW DURATION IN NECHES BASIN

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Contents

Introduction

Human water users have come to realize that for streams and rivers to maintain healthy ecology, a certain level of flow is necessary. However, setting a simple minimum flow level is not sufficient since the water systems have dynamic characters varying over time and flow conditions. These varying flow needs of a stream are quantified and collected as "environmental flows". Typically environmental flows include four in-stream flow components which are subsistence flows, base flows, high flow pulses and overbank events (Opdyke et al 2014). This term project focuses on characters of high flow pulses.

High pulse flows are defined as "relatively short-duration, high flows within the stream channel that occur during or immediately following a storm event" (Texas Administrative Code §298.1 2011). For each regulated location, three essential components of pulse flows are defined as shown in Figure 1: a) a trigger flow rate (Q, cfs) that indicates the beginning of a pulse event as distinct from a normal flow, b) a duration (D, days) giving the length of time the pulse event lasts before flow returns to a normal level and c) a volume (V, acre-ft) of water that flows past a chosen point during the pulse event. The trigger flow rate indicates when a water right holder must stop diverting water, while duration and volume serve as alternate indicators of when a water right holder may start diverting water again.

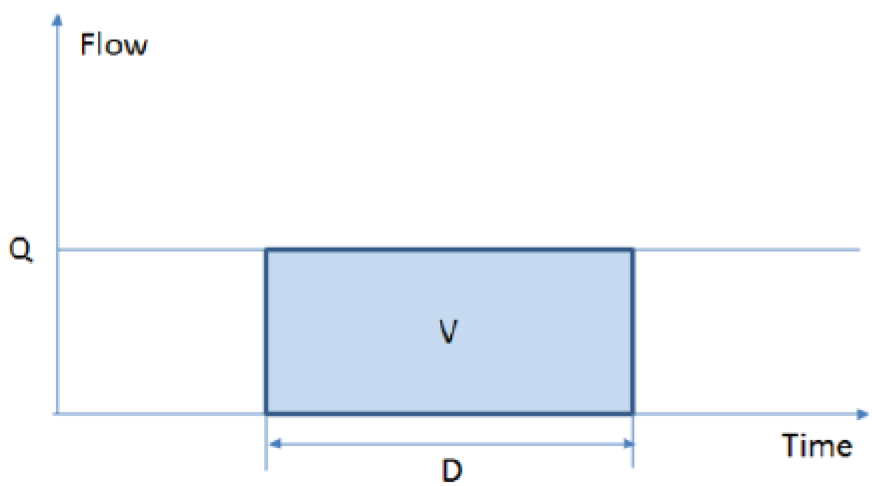

Figure 1Illustration of the Components of an Environmental High Pulse Flow

Currently in Texas, the environmental flow standards are established only at a few points in each river basin. However, environmental flow regimes are needed throughout each basin at any point with water right. In order to solve this problem, a straightforward Pulse Scaling Method is developed by Dr. Maidment and his former student Alison Wood, to transpose the pulse event characteristics from one regulated location to another unregulated location. It is found that some characteristics of pulses have a degree of regional consistency. Specifically, while pulse trigger flow rates and volumes tend to vary from location to location, durations tend to remain relatively constant within geographic regions (Wood, 2013). It appeared to be interesting to study the one character, duration, which maintains a degree of consistency while it has many reasons to vary due to the complexity in real flows.

Data Sources

This research described here looks at using output from one of the flow models in the National Flood Interoperability Experiment (NFIE) to examine the duration at different locations (with or without written standards) in Neches basin. The NFIE output files are provided by Peirong Lin, a UT Austin graduate student in Geoscience School.

The environmental flow standards are adopted by Texas Commission on Environmental Quality (TCEQ). The standard documents are available on TCEQ's website in the environmental flows section. At the same time, in recognizing which unregulated locations are worth studying, a shapefile (used in ArcGIS mapping) with the locations of water diversion points is also provided by TCEQ.

The Neches basin and corresponding flowlines are delineated and mapped in ArcGIS with the NHDPlus dataset. Historical stream discharge record is acquired from the USGS website.

Methods

The target river basin and flowlines in that basin is obtained from NHDPlus dataset with the same approached we used in Exercise 2. The gages with written standards are typed in to excel and added to the Neches basin map as a shapefile layer. An example of the environmental standards is shown in Figure 2 (Texas Administrative Code §298.280, 2011). Once the preparation of map is finished (as shown in Figure 3), certain dates are required to request for outputs from NFIE.

United States Geological Survey Gage 08032000, Neches River at Neches

Season	Subsistence	Base	Pulse
Winter	51 cfs	196 cfs	1 per season Trigger: 833 cfs Volume: 19,104 af Duration: 10 days
Spring	21 cfs	96 cfs	2 per season Trigger: 820 cfs Volume: 20,405 af Duration: 12 days
Summer	12 cfs	46 cfs	1 per season Trigger: 113 cfs Volume: 1,339 af Duration: 4 days
Fall	13 cfs	80 cfs	2 per season Trigger: 345 cfs Volume: 5,391 af Duration: 8 days

cfs = cubic feet per second
af = acre-feet

Figure 2 Example of Environmental Flow Standards at Neches River at Neches, TX

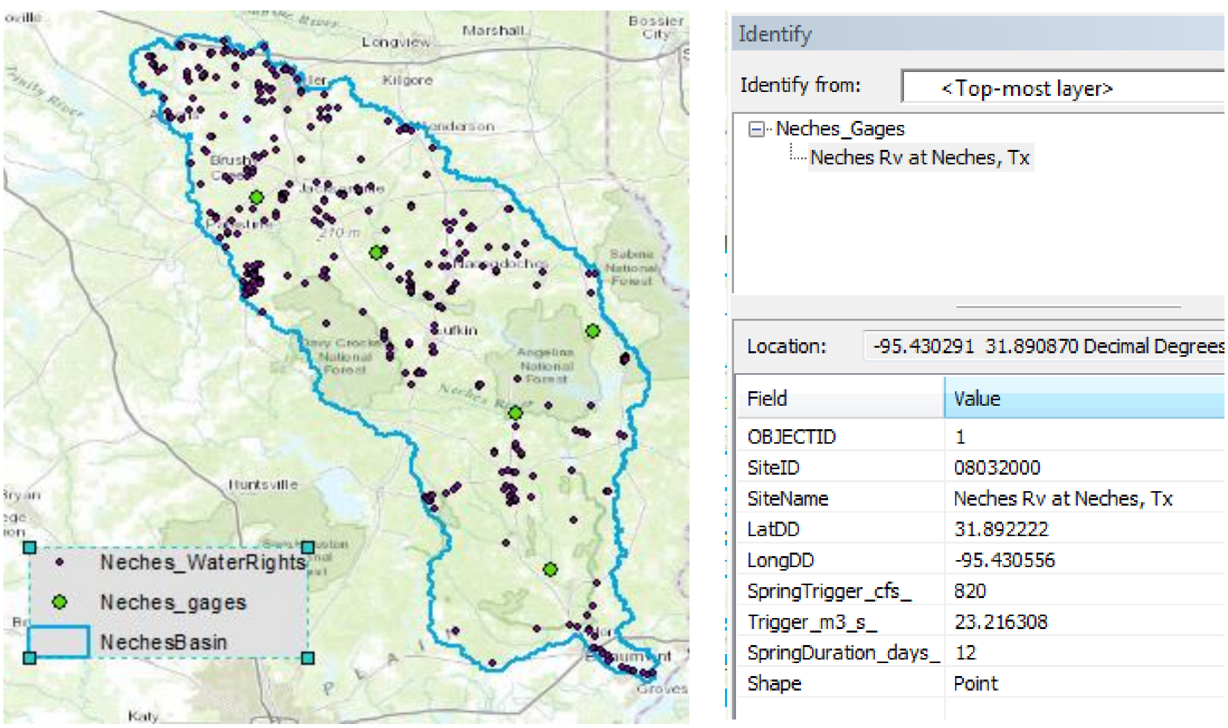

Figure 3 Illustration of Neches Basin with Feature Identify Example for Regulated Gage

When it comes to determining time period of interest, USGS National Water Information System data is used in detecting the occurring of pulse flow events at selected gages in 2015. In this study, Neches River Basin in Texas is the research area and gage "Neches at Neches River" (USGS site id 08032000) is the gage of interest. After several attempts, it is detected that there should be a potential pulse event between Jun 17th 2015 and Jul 2nd 2015, as illustrated in Figure 4 (USGS NWIS).

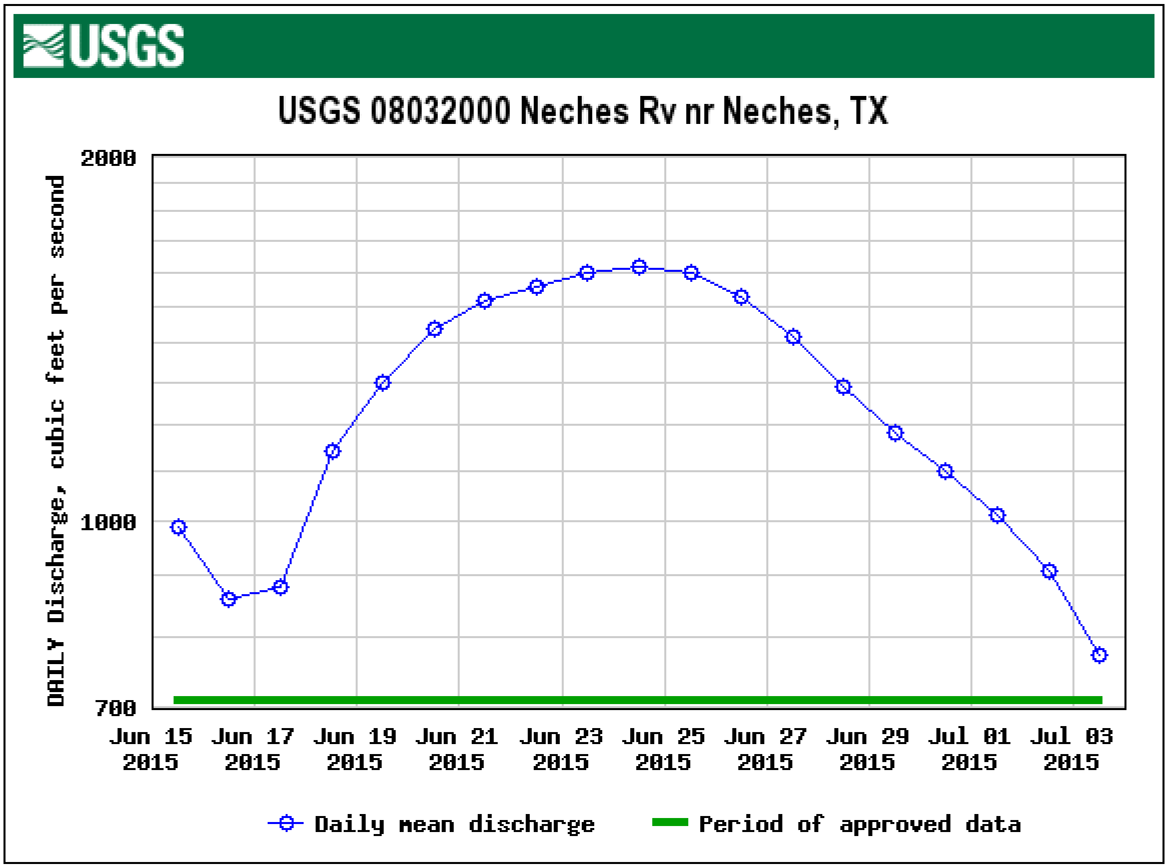

Figure 4 Flow Chart with USGS Daily Discharge Record in a Selected Time Period

With the time period determined, output files are obtained from NFIE, or more specifically, a model called RAPID (Routing Application for Parallel computation of Discharge) developed by Dr. Cedric David. The output from RAPID provides flow in reaches throughout the continental United States based on NHDPlus flow network, which makes it possible to study on the flow characteristics anywhere the NHDPlus flowlines reach in our research area. The output files are in NetCDF format, which can be used directly in ArcMap (multidimensional tools). There is a detailed tutorial describing how to ingest the model output in ArcMap and use it to create either maps of all reaches at specific time steps or hydrographs of specific reaches at all time steps. In this project, the hydrographs of select locations are created to be studied on.

In selecting locations of interest, two types of locations are defined according to Wood's master's thesis: primary locations and secondary locations. Primary locations are places where the characteristics are established in existing documents adopted by TCEQ. Secondary locations are places where the environmental flows standards are not established but should be evaluated according to the standards at the primary location. Secondary locations are selected among the locations with TCEQ permitted water rights, by visually looking at the Neches Basin map (Figure 3).

Results and Discussion

In Neches River Basin, the gage named Neches at Neches River (COMID: 4452936) is selected to be studied as a primary location. Four secondary locations are selected around Neches at Neches River, which are respectively 4451568, 4452698, 4454338, and 4453624, represented by NHDPlus COMIDs. As illustrated in Figure 5, among these secondary locations, 4451568 and 4452698 are upstream of the primary location, where 4451568 is on a tributary while 4452698 is on the main stream. In the meantime, 4454338 and 4453624 are downstream from the primary location, where 4453624 is on a tributary while 4454338 is on the main stream.

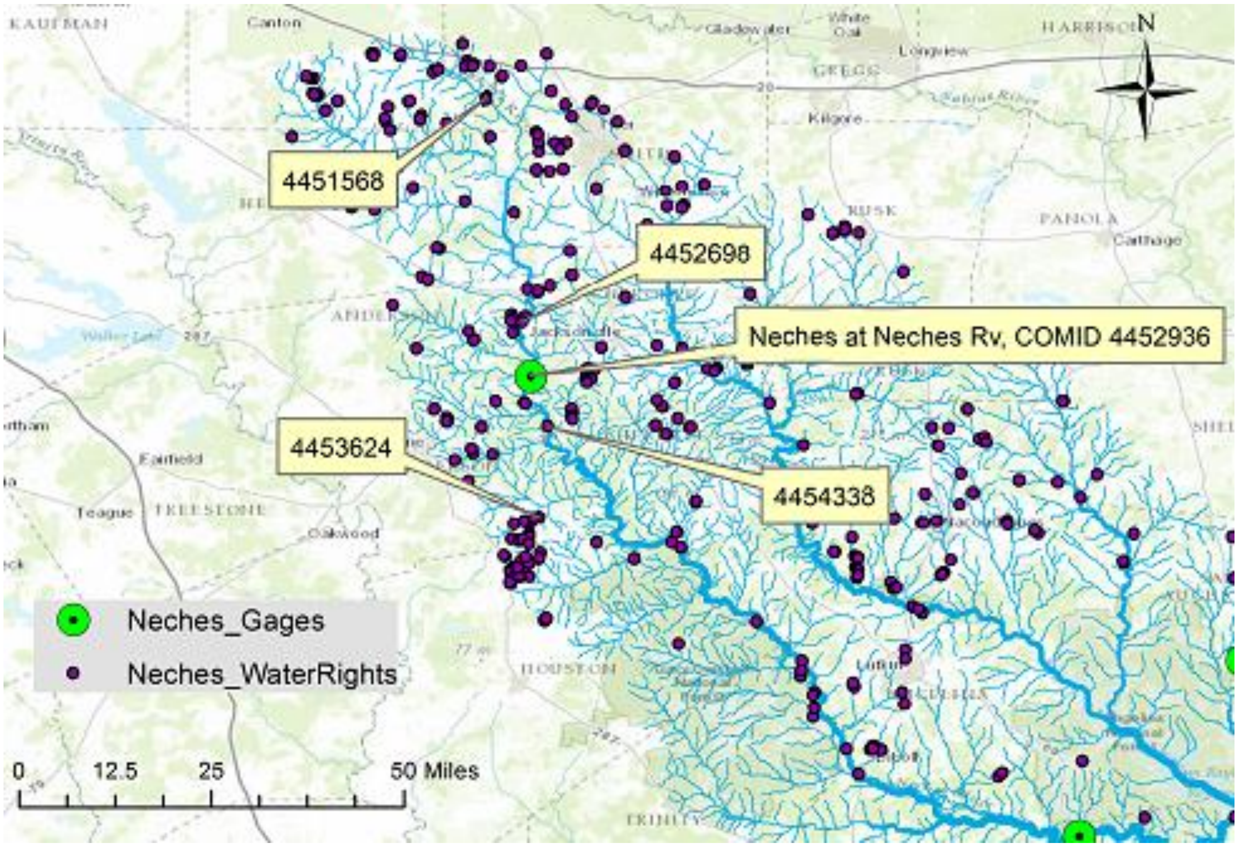

Figure 5 Illustration of the Selected Primary and Secondary Locations in Neches Basin

Hydrographs are generated for the five selected locations as shown in Figure 6. The time period that is actually explored in this study is from Jun 16th 2015 to Jun 21st 2015, which is about 1/3 of the long time period determined with USGS data. This is because only one complete pulse flow event is discovered when plotting with NFIE output data, which locates in the shorter time period mentioned above. As we can see from Figure6, the pulse events begins approximately in the afternoon on June 17th for all of the five locations, yet the following progress varies quite differently for each location.

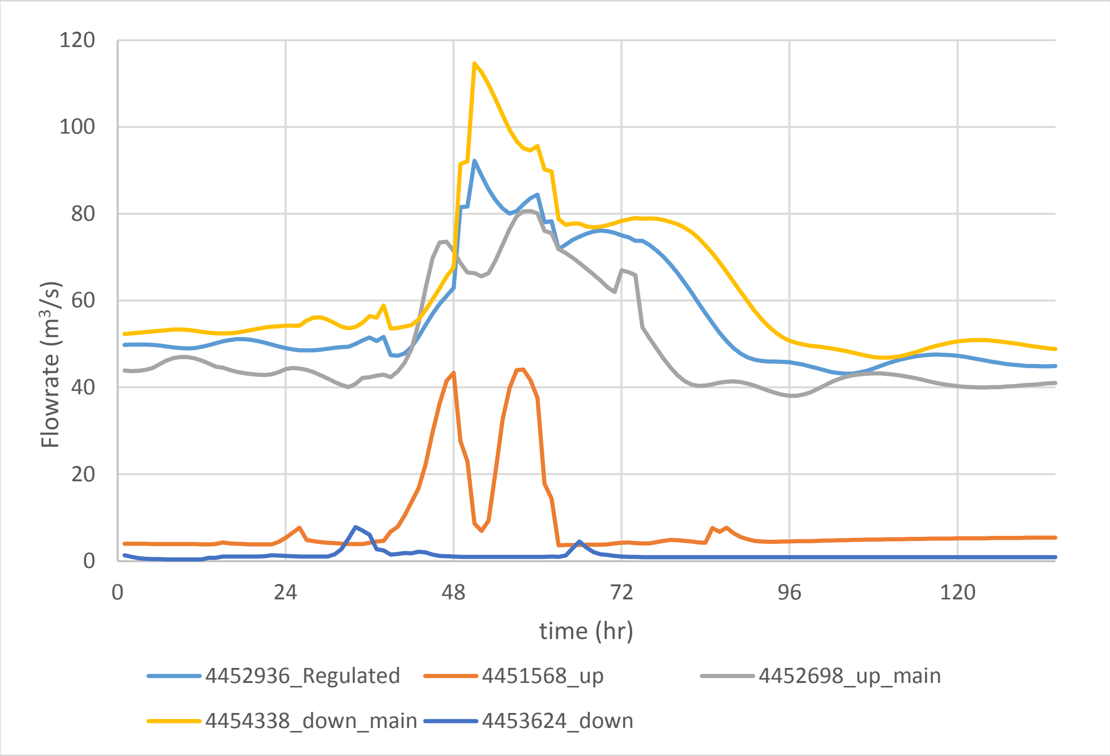

Figure 6 Hydrographs at Selected Locations in Neches Basin

In order to having a better illustration of the comparison of the components, especially the duration of a pulse event, the five hydrographs are integrated into one graph, as shown above in Figure 6. It is seen that the hydrographs could be obviously divided into two groups. One group consists of 3 reaches on the main stream, which are represented by the upper three flow charts in Figure 6. By reading directly from the graph, the pulse event durations for these locations on the main stream are relatively close, which are approximately 1.7 days (4452698), 2 days (4452936) and 2.5 days (4454338). Meanwhile, the duration shows an increasing trend when the select location comes from upstream to downstream. The other group consists of 2 reaches on the tributaries. The upstream reach 4451568 has an about 1 day pulse duration, while the drop between the two peaks could be explained by errors from NFIE modeling. The downstream reach 4453624 shows two distinct small pulses, both last for just a few hours. Furthermore, the durations for all of the five locations are much less than expected. Since it is 12-days as written in the standards (Figure 2) for the primary location 4452936, both primary location and secondary locations are expected to possess similar flow pulse durations in this study.

Conclusion

As discussed in the results, the consistency of pulse event duration from location to location in the same region does not meet our expectation. Nonetheless, the scale (length) of the durations is much less than the standard value in the written document. This situation probably results from a wrong approach in processing and illustrating NFIE data. Since in the environmental high pulse flow standards durations are given in days, usually greater than 5 days, it is more reasonable to process and summarize the NFIE output data based on days, although they are given in one-hour increment time steps. Also, only five locations in one season is not enough in examining the pulse flow events in a river basin, it is more reasonable to test on different seasons with different conditions, and use statistical methods to summarize the results. It is believed that with the improved approaches, the observed pulse event durations should be more consistent from location to location. Unfortunately, due to the lacking of efficiency in extracting and processing data by ArcGIS, this idea is failed to be accomplished.

Although there is not a satisfactory result reached in this study, thoughts and suggestions are provided for any continuing studies. Meanwhile, several things were learned from the research process. It is recognized that ArcGIS is a great tool not only for visualizing spatial data, but also for integrating all kinds of information on one map as different layers. Furthermore, this study illustrates a good aspect of incorporating NFIE forecasting data in water resources research application utilizing ArcGIS tools is practiced.

Acknowledgements

I would like to thank Dr. Maidment and Dr. Tarboton for introducing us to applying ArgGIS in Water Resources research. I would also like to thank Dr. Maidment in giving guidance and timely feedbacks on my project topic and progresses. Thanks to Peirong Lin who provides valuable NFIE output data and instructions on incorporating them in ArcGIS.

References

NHDPlus http://www.horizon-systems.com/nhdplus/

Opdyke, D. R., Oborny, E. L., Vaugh, S. K., & Mayes, K. B. (2014). Texas environmental flow standards and the hydrology-based environmental flow regime methodology. *Hydrological Sciences Journal*, *59*(3-4), 820-830.

Texas Administrative Code §§ 298.1, 298.225, 298.280. 2011.

USGS National Water Information System. http://water.usgs.gov/usa/nwis/

Wood, A. P. (2013). Decision support for active water management (master's thesis).