Preliminary IHA Analysis for the Middle Fork Willamette River at Jasper OR

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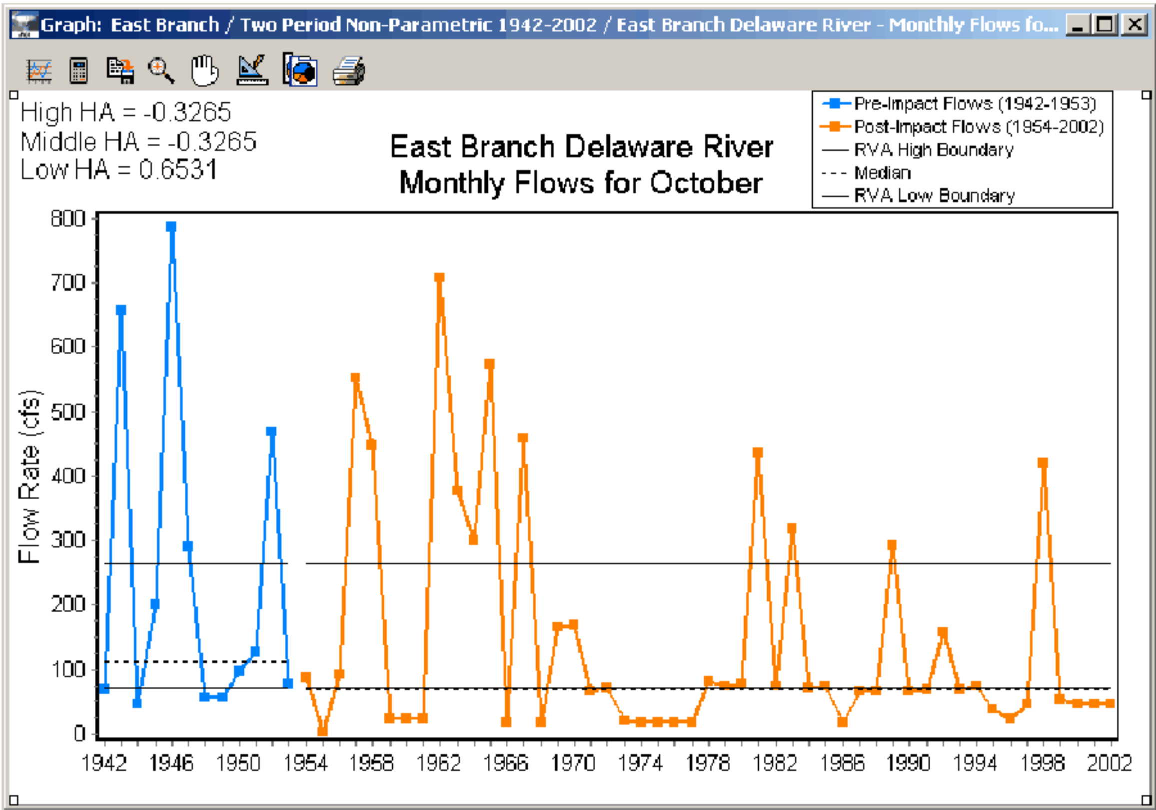
Indicators of Hydrologic Alteration

The Indicators of Hydrologic Alteration software (IHA) organizes long periods of hydrological data into sets of ecologically important parameters. The scientific basis of this program is summarized in several papers (Richter et al. 1996, Richter et al. 1997). These papers and the IHA software itself can be downloaded from the web site: nature.org/freshwater (specifically: http://www.nature.org/initiatives/freshwater/conservationtools/index.html).

Thirty-three IHA parameters can be lumped into five groups: (1) magnitude of monthly flow conditions; (2) magnitude and duration of extreme flow events (e.g. high and low flows); (3) the timing of extreme flow events; (4) frequency and duration of high and low flow pulses; and (5) the rate and frequency of changes in flows. For these parameters, the IHA can perform a Range of Variability Analysis. For each of the parameters, IHA calculates a Hydrologic Alteration factor, which is calculated as follows:

1. For each parameter, IHA divides the full range of 'pre-impact data' into three different categories, generally percentiles (e.g., lowest third, middle third, highest third).
2. The program then analyzes the 'post-impact' data and compares the observed distribution of data with the distribution expected from the pre-impact data.
3. HA factor = (observed frequency-expected frequency)/expected frequency
4. A positive HA factor means that the frequency of values in the category (percentile grouping) has increased in the post-impact period, while a negative HA factor means that the frequency of values in the category (percentile grouping) has decreased in the post-impact period

For example, if a dam was able to store and attenuate all high flow events, then, for floods, the HA factor for the 'high category' (highest third of all flows from pre-impact data) would be negative, while the 'low category' (lowest third of all flows from pre-impact data) would be positive. For a second example, see the figure below. In this example, there are fewer than expected October flows in the 'high' category (highest third of pre-impact flows): during the 48 years post impact, one would expect 16 years to fall into the 'high' category, but only 11 do. Thus, the High HA factor is negative.



Ecosystem Flow Components
The IHA also calculates 34 parameters that relate to Ecosystem Flow Components (EFCs): low flows, extreme low flows, high flow pulses, small floods and large floods. The IHA default for defining floods is that small floods have a recurrence interval ≥ 2 years and < 10 years and large floods are those with a recurrence interval ≥ 10 years.

<u>Methods for Jasper</u>
For this IHA analysis, unregulated flow data were provided by the Army Corps of Engineers. I acquired regulated flow data from the USGS website for gauge 14152000. Based on information on the website that the last major dam upstream was completed in 1966, I began the analysis on 10/1/1967 (water year 1968) for both the unregulated and regulated data. The unregulated flow data spanned from 10/01/1967 to 9/30/2004 while the regulated flow data spanned from 10/01/1967 to 8/31/2006.

A primary function of the IHA software is to compare to hydrological data sets and calculate a variety of statistics to assess the degree of hydrological alteration between them. The program is set up to process a single data set and the user is asked to input the year of the 'impact.' The simplest case is for a long hydrological record that has a single dam built at some point of time; the IHA then divides the data set into a 'pre-impact' period (before the year of dam completion) and 'post-impact' period. The Willamette data sets represent a different approach: comparing unregulated and regulated hydrological data from the same period of record. Within the IHA I defined the unregulated data as 'pre-impact' and the regulated data as 'post-impact.' However, because the IHA requires a single data set with a user-defined year of impact, I created 'dummy' years for the post-impact data (regulated data) with an impact date of 10/1/2004. Within the analysis you will see that the post-impact flows are represented by the water years 2005 to 2043. Keep in mind that theses post-impact years are the same years as the pre-impact data (with two extra years in post-impact) but for the purposes of the IHA analysis they've been labeled with future years.

Results

The regulated Middle Fork has higher monthly flows from the summer to early winter (July through December) and then, beginning in January, considerably lower monthly flows in the winter and spring (Figure 1). These changes are also reflected in Figure 2, which shows all Hydrologic Alteration (HA) factors, and Figure 3, which emphasizes the highest HA factor for each parameter. Monthly flows from July to December show that the regulated flows have large positive values in the high RVA category (i.e., the regulated period of record has more than the expected number of years in the high range of variability category based on the unregulated flows). Conversely, monthly flows from February to May have large positive values in the low RVA category.

Figure 4 partitions the hydrograph into Ecosystem Flow Components for the total period of record (pre-impact and post-impact) with the arrow indicating the division between the unregulated and regulated flows (remember that the years after 2005 are 'dummy' years and actually represent the regulated flows over the same time period as the unregulated, or pre-impact flows). What IHA defined as small and large floods from the unregulated data no longer occur within the regulated data, as indicated by the lack of green and red spikes after the arrow. This is also reflected in the HA values for the one-day and three-day maximum flows, which have large positive values in the low RVA category and large negative values in the middle and high RVA categories (Figure 2). In fact, for one-day maximum floods, the high and middle RVA categories have the maximum possible negative value of -1, indicating that flows in these RVA categories never occurred in the regulated data. This can also be visualized examining Figure 5 which shows the distribution of one-day maximum flow values. The highest one-day maximum flow in the regulated data set was 22,700 cfs, which is just below the 25th percentile of the distribution of one-day maximum flows from the unregulated data. The highest one-day maximum flow in the unregulated data was 68,350 cfs. The median one-day maximum flow dropped in half, from 30,800 cfs in the unregulated data to 16,300 cfs in the regulated data.

The seven-day maximum flows are also reduced in the regulated data, though not as dramatically as the one-day maximum flows (Figure 6). However, no flows in the regulated data are found within the high RVA category.

The 30-day maximum flow has changed little between the unregulated and regulated data sets (Figure 7). (Note that in Figures 5 and 6 the two solid lines for the post-impact data were showing the RVA category boundaries, which are determined by the pre-impact data; this is to emphasize the absence of regulated flows in the high RVA category (7-day maximums) and the high and middle RVA categories (one-day maximums). Here in Figure 7 the two solid lines are the 25th and 75th percentiles from the regulated data; this is to emphasize that the distributions have changed very little).

As stated earlier, the EFCs 'small floods' and 'large floods' do not occur in the regulated data set (Figure 8). The peak of high flow pulses are somewhat diminished in the regulated data compared to the unregulated data (Figure 9) while the duration of high flow pulses is similar between the data sets (Figure 10).

Low flows in the summer and fall are elevated in the regulated data compared to the unregulated data (Figures11-13). The median of monthly flows increased from 1000 cfs for unregulated flows in August to 2500 cfs for regulated flows (Figure 11) and from 1000 cfs for unregulated flows in October to 3500 cfs for regulated flows(Figure 12). The seven-day minimum flows have approximately doubled from the unregulated data (median = 737 cfs) to the regulated data (median = 1459 cfs) (Figure 13).

<u>Information from USGS website for Jasper:</u>

Station operated in cooperation with the U.S. Army Corps of Engineers.

14152000 MIDDLE FORK WILLAMETTE RIVER AT JASPER, OR

LOCATION.--Lat 43° 59'54", long 122° 54'17", in SW 1/4 SW 1/4 sec.14, T.18 S., R.2 W., Lane County, Hydrologic Unit 17090001, on right bank 25 ft downstream from highway bridge at Jasper, 0.1 mi downstream from Hills Creek, and at mile 195.0.
DRAINAGE AREA.--1,340 mi^2.
PERIOD OF RECORD.--September 1905 to February 1912, July 1913 to March 1917, October 1952 to current year. Monthly discharge only for some periods, published in WSP 1318.
GAGE.--Water-stage recorder. Datum of gage is 513.45 ft above NGVD of 1929. September 1905 to February 1912 and July 1913 to March 1917, nonrecording gage at approximately same site at datum about 1.5 ft higher. Oct. 22, 1952, to Sept. 30, 1953, nonrecording gage at site 25 ft upstream at same datum.
REMARKS.--Flow regulated since 1953 by Lookout Point Lake (station 14149000), since 1961 by Hills Creek Lake (station 14145100), and since 1966 by Fall Creek Lake (station 14150900). Continuous water-quality records for the period October 1953 to September 1987 have been collected at this location.
EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 94,000 ft^3/s Nov. 23, 1909, gage height, 17.4 ft, datum then in use, from graph based on gage readings, from rating curve

extended above 42,000 ft^3/s; minimum discharge, 366 ft^3/s Dec. 5, 1954.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 15,700 ft^3/s Jan. 18, gage height, 8.36 ft; minimum discharge, 1,460 ft^3/s May 6, July 4.