Lower Turwar Creek Restoration Effectiveness Monitoring Project

SP-14

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1. Introduction

The Yurok Tribe Environmental Program (YTEP) has been coordinating with the Yurok Tribe Fisheries and Watershed Restoration Programs since 1996 to identify locations to monitor the effects of land management activities and restoration projects. YTEP installed continuous turbidity, water temperature and water level monitoring station in Lower Turwar Creek to monitor the effectiveness of current and future restoration projects. The location of this monitoring station was installed downstream of the upslope and instream restoration projects that were implemented by the Yurok Watershed Restoration and Fisheries Programs.

The objectives of operating this monitoring site are to:

1. To establish baseline conditions across a wide array of water years
2. To track long-term trends through consistent, comparable sites and methods
3. To document effects of various short-term and long-term management and restoration activities throughout the Turwar Creek watershed.

In addition to installing and operating this continuous monitoring station YTEP has suspended sediment sampling in Lower Turwar Creek adjacent to the monitoring station. This sampling is done to develop a relationship between turbidity and suspended sediment over a range of water years and storm events. YTEP also performed macroinvertabrate sampling in Lower Turwar Creek in the Spring of 2006, 2007, 2008 and 2009. This monitoring has been done to assess the benthic macroinvertebrate assemblages prior to and following the restoration work. The macroinvertebrate monitoring site was located adjacent to the instream riparian restoration project and downstream of the upslope restoration projects.

1. a. Lower Turwar Creek Monitoring Station

The Lower Turwar Creek Monitoring Station was installed in October 2007 just downstream of the Highway 169 bridge that crosses Turwar Creek (see Figure 1). The continuous water level height began recording on October 30, 2007 and the turbidity and water temperature probe was installed and began operating on November 2, 2007. The water level height, water temperature and turbidity data is collected until the stream flow is affected by the lower control and the stream reaches PZF (point of zero flow) (See figure 4). Historically this reach of Lower Turwar Creek has been intermittent. However, the exact times that the channel goes dry in the Spring or Summer is determined by the amount of precipitation received in the late winter and early spring months. Water year 2008 and 2009 received below average precipitation.

The monitoring station begins collecting data once the stream channel starts to flow again in the Fall. Again this is based on when the Fall rains start, stream morphology, and amount of precipitation during storm events. This monitoring station will continue to be operated into the future and the data will be published with CWA Section 106 funding that YTEP receives.

The Lower Turwar Creek Monitoring Station data is available real-time at http://exchange.yuroktribe.nsn.us/lrgsclient/stations/lowturwar.php. The real-time component allows staff to understand and keep track of the current stream conditions. This allows staff to visit sites to take flow measurements and collect suspended sediment samples during high flow events. Real-time accessibility also ensures a more complete data set of high quality because the operator can determine when equipment is malfunctioning and visit the site to correct any problems.

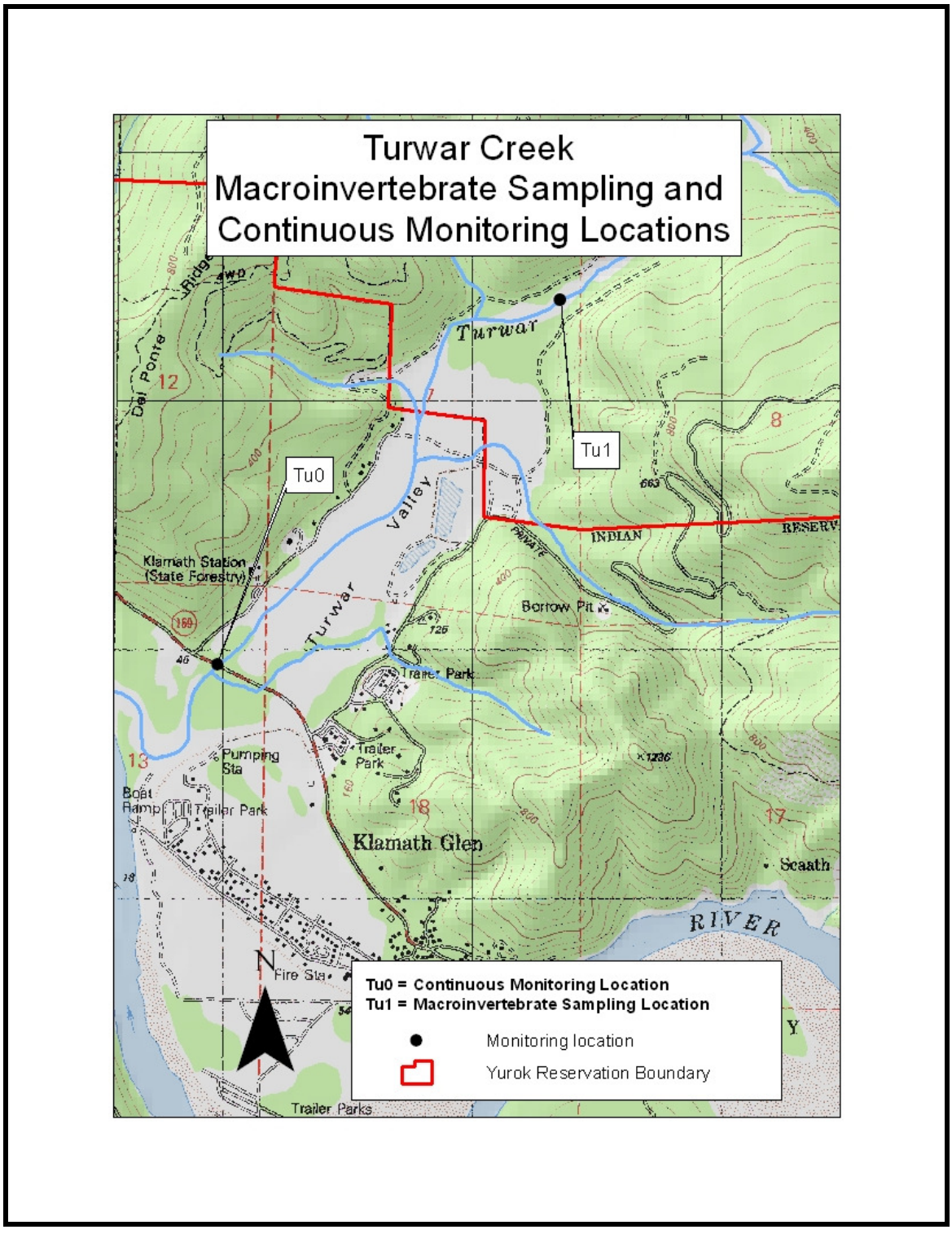


Figure 1. Map of Lower Turwar Creek Continuous Monitoring and Macroinvertebrate Sampling Locations.

Figures 2 and 3. Photo of Lower Turwar Creek Monitoring Station and Monica Hiner programming the datalogger.

Figure 4. Photo of Lower Turwar Creek going subsurface.WY09

Figure 5. Photo of automated pump sampler used to collect unattended water samples to be analyzed for suspended sediment concentrations, Lower Turwar Creek, WY 2008.

Figure 6. Photo of Ken Fetcho mounting staff plate on bridge abutment Lower Turwar Creek, WY 2008.

Figure 7. Photo of bridge crane mounted flow measuring equipment at Highway 169 bridge crossing at Lower Turwar Creek, December 27, 2007.

Figure 8. Photo of Micah Gibson operating the bridge crane, Lower Turwar Creek, December 27, 2007.

1. b. Lower Turwar Creek Macroinvertebrate Sampling

YTEP collected macroinvertebrate samples in Lower Turwar Creek on April 28, 2006, May 7, 2007, April 30, 2008 and April 21, 2009. This sampling was part of an effort to assess the physical/habitat and biological conditions on the lower reach of Turwar Creek. This data was added to YTEP macroinvertebrate data as part of an endeavor to build a multi-year dataset on the lower Klamath River. This summary is part of YTEP's comprehensive program of monitoring and assessment of the chemical, physical, and biological integrity of the Klamath River and its tributaries in a scientific and defensible manner.

Figure 9. Photo of Lower Turwar Creek macroinvertebrate sampling reach (looking downstream), April 28, 2006.

Figure 10. Photo of Lower Turwar Creek macroinvertebrate sampling reach,(looking upstream) May 7, 2007.

Figure 11. Photo of Lower Turwar Creek macroinvertebrate sampling reach (looking downstream), April 21, 2009.

2. Methods

2. a. Lower Turwar Creek Monitoring Station

Gage height is measured at the Lower Turwar monitoring station using a WaterLog® H-350XL Pressure Transducer/Data Collection Platform. The following parameters are measured at each site on a fifteen-minute time interval throughout the year: date, time, stage, air temperature (inside the gaging box), and battery voltage. Turbidity and water temperature are also measured at a 15 minute interval using a digital turbidity sensor (DTS-12) manufactured by Forest Technology Systems, Inc.

During site visits, gage height was compared visually to water level on a fixed, graduated staff. If gage height was adjusted during site visits, it was noted in the site field notebook and the data file was flagged accordingly. Data is downloaded from the gaging station using a SanDisk Compact Flash Memory Card. At sites with turbidity booms, the

location of the turbidity probe is monitored and adjusted throughout the season to ensure that they are positioned above the streambed and approximately mid-water column depth to ensure accurate data collection.

Flow measurements are collected at or near each gaging station during monthly site visits and periodically during high flow events in winter months. Stream discharge is measured by wading or with a bridge crane USGS methodology (Buchanan and Somers 1969, Nolan and Sultz 2001). Discharge is measured using either a Price AA® or Pygmy® flow meter, depending on stream depth, and an AquaCalc® flow computer. Flow measurements taken were used to create a rating curve based on USGS methodology (Kennedy 1984). To estimate a continuous flow record at each gaging station, the rating curve equation was applied to gage height datum.

YTEP also periodically collected suspended sediment samples at gaging stations during WY07, WY08, and WY09. Depth integrated samples were collected using either a US-D-48 wadable sediment sampler or US-D-74 sampler attached to a crane for non-wadable sampling. YTEP followed Equal Width Increment (EWI) methodology developed by USGS (Edwards and Glysson 1998). Sediment samples were analyzed by Graham Matthews and Associates (Arcata, California) following all USGS protocols to determine suspended sediment concentrations (SSC). See table 1 for the samples collected in water year 2008 and 2009. YTEP has taken box samples as well, which are single samples at the deepest fastest part of the stream flow. Given enough box samples a correlation can be made between the box samples and the DIS (Depth Integrated Sampling) so in future storm events YTEP is much more efficient with our time, yet still highly accurate in data collection and representation of the SSC.

2. b. Lower Turwar Creek Macroinvertebrate Sampling

YTEP sampled benthic macroinvertebrate populations in Lower Turwar Creek during the spring from 2006 to 2009. Sampling was performed using the multi-habitat methods located in the State of CA Surface Water Ambient Monitoring Program (SWAMP) *Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California February 2007* that the DFG has adapted from the US EPA's "Rapid Bioassessment Protocols of use in Streams and Rivers".

Although this protocol was not finalized until February 2007 a draft version was available to YTEP and was used in the spring of 2006 to collect its macroinvertebrate samples. The methods used are identical to the ones laid out in the above mentioned 2007 protocol. This protocol also includes the collection of water quality parameters and physical habitat conditions in the channel and the riparian zone. This report does not contain this information.

The parameters measured include:

- Epifaunal Substrate/Available Cover

- Embeddedness
- Instream Habitat Complexity
- Bank Stability
- Bankfull and wetted width
- Pebble Count
- Vegetative Protection
- Riparian Vegetative Zone Width
- Canopy Cover
- Stream Flow
- Physical water quality parameters
- Micro and macro algal percent cover in stream.

A variety of quality control (QC) measures were undertaken in the macroinvertebrate sampling. Quality control is defined as the routine application of procedures to obtain prescribed standards of performance in the monitoring and measuring process (QAPP, 2001). Sample labels were properly completed, including the sample identification code, date, stream name, sampling location, and collector's name and placed into the sample container. The outside of the container was labeled with the same information. The chain-of-custody forms included the same information as the sample container labels. After sampling had been completed at a given site, all nets, pans, etc. that had come in contact with the sample were rinsed thoroughly, examined carefully, and picked free of organisms and debris. The equipment was examined again prior to use at the next sampling site.

Data generated in the laboratory are reviewed by DFG prior to being released internally or to an outside agent. DFG data review of 2006 results reported that the taxonomists ID's are accurate and the data is acceptable. Laboratory processing is contracted to Jonathan Lee, a qualified local California Stream Bioassessment Protocol (CSBP) taxonomist and California Bioassessment Laboratories Network (CAMLnet) member. The CSBP has three levels of Benthic Macroinvertebrate (BMI) identification. Level 3 is the professional level equivalent and requires identification of BMI's to a standard level of taxonomy, usually the genus and/or species.

After processing the samples, the biological matrices are received from the taxonomist in an Excel spreadsheet format identifying the sample ID and the breakdown of BMI species into standard taxonomic levels.

3. Results

3. a. Lower Turwar Creek Monitoring Station

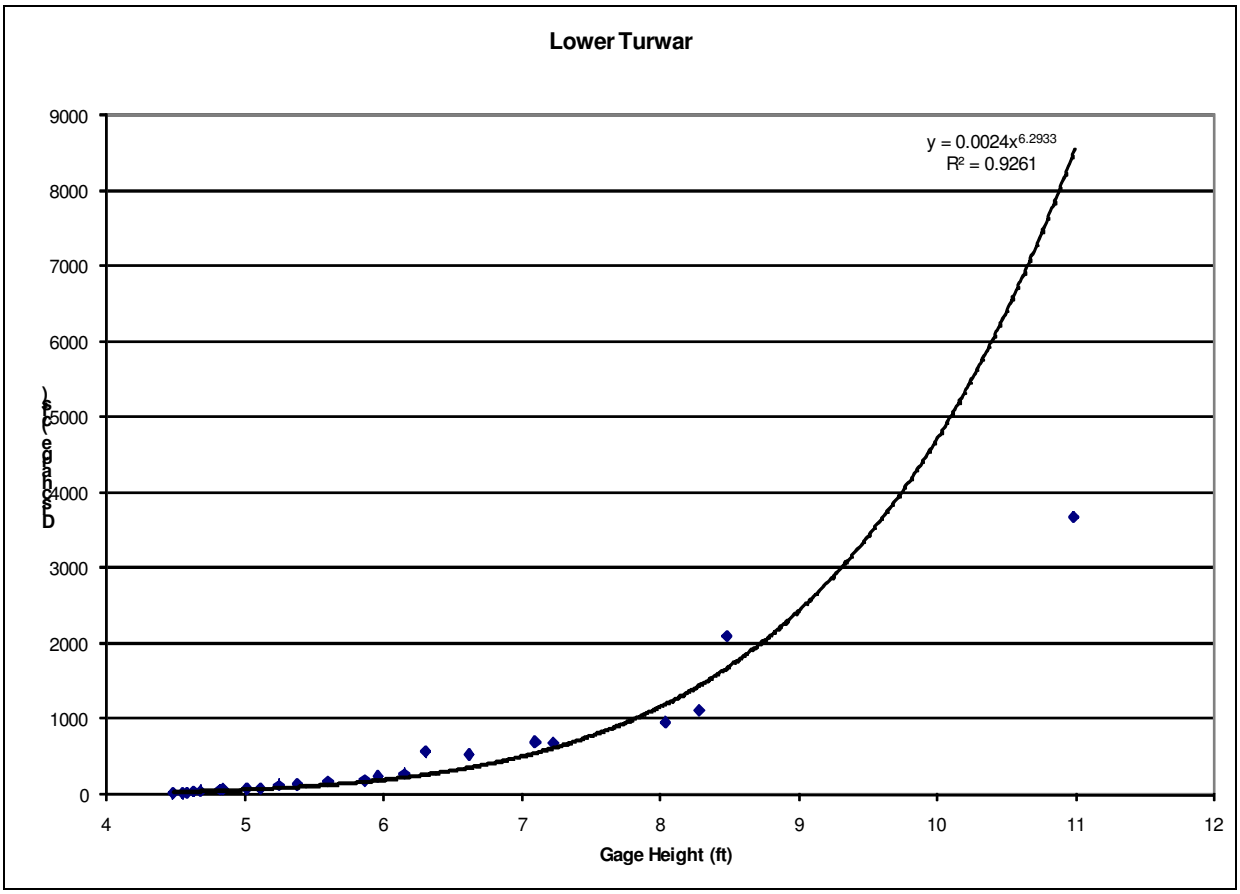
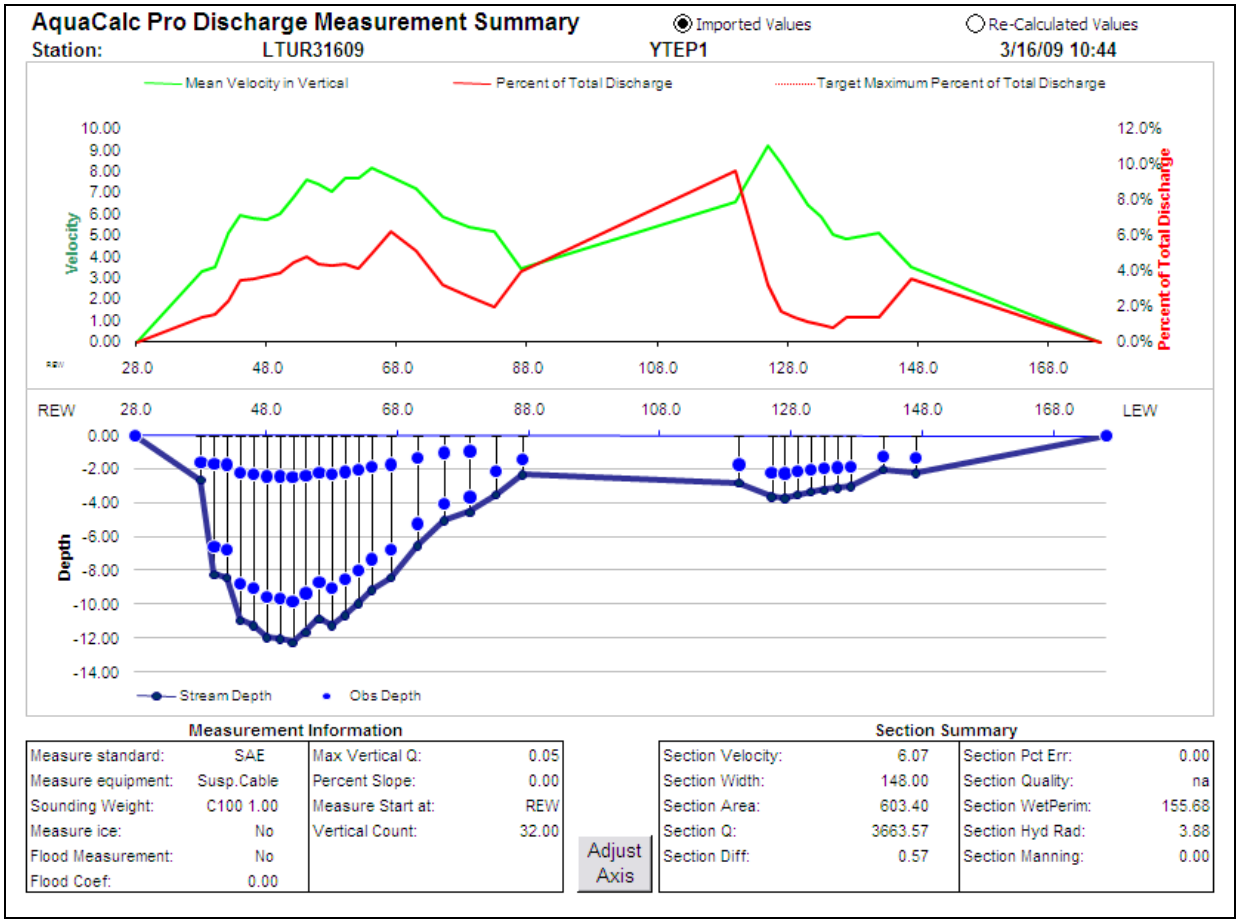


Figure 12. Rating curve expressing relationship between stage height and stream discharge in cubic feet per second (cfs), Lower Turwar Creek WY 2008 to present



..Figure 13. Highest stream measurement from Lower Turwar bridge 03/16/2009

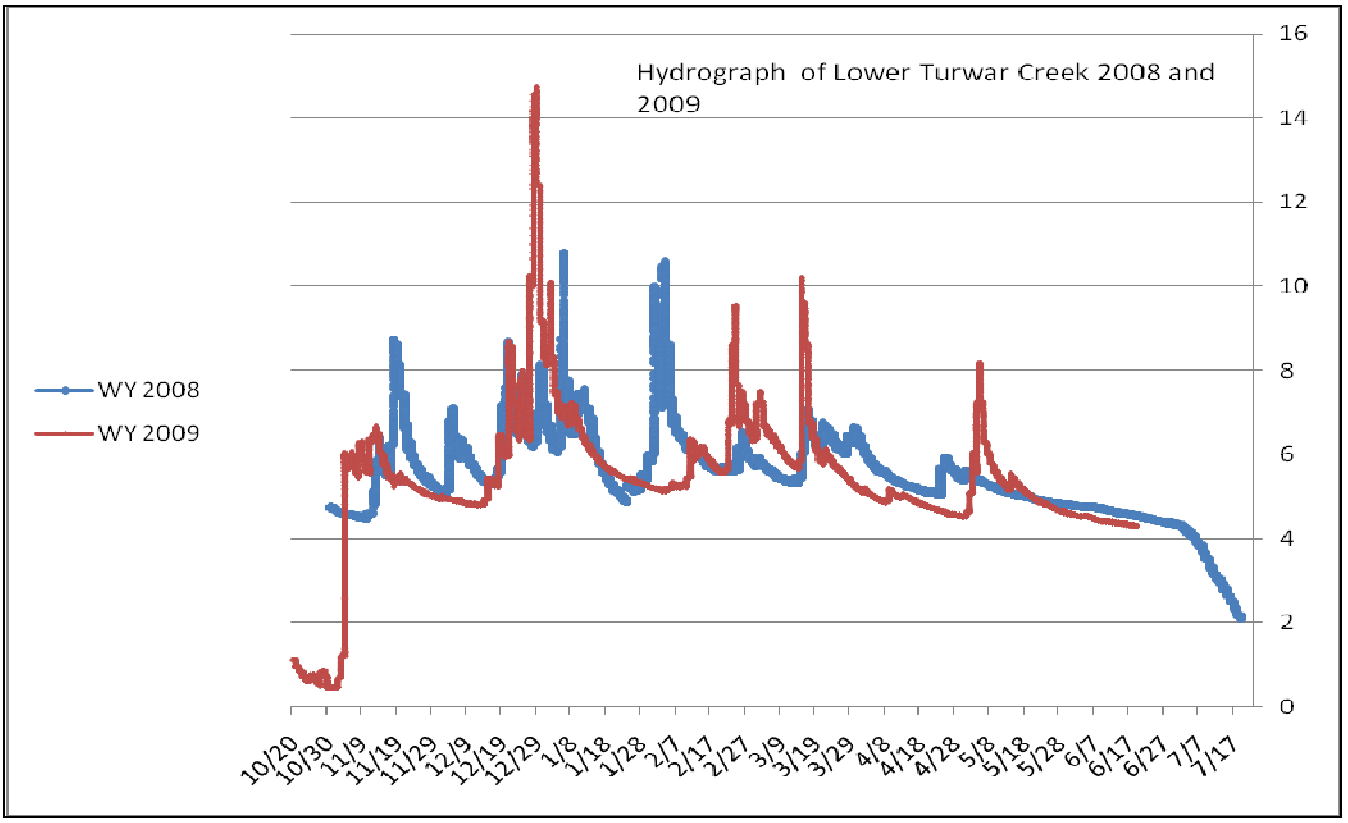


Figure 14. Stream hydrograph for Lower Turwar Creek, Water Year 2008 and 2009

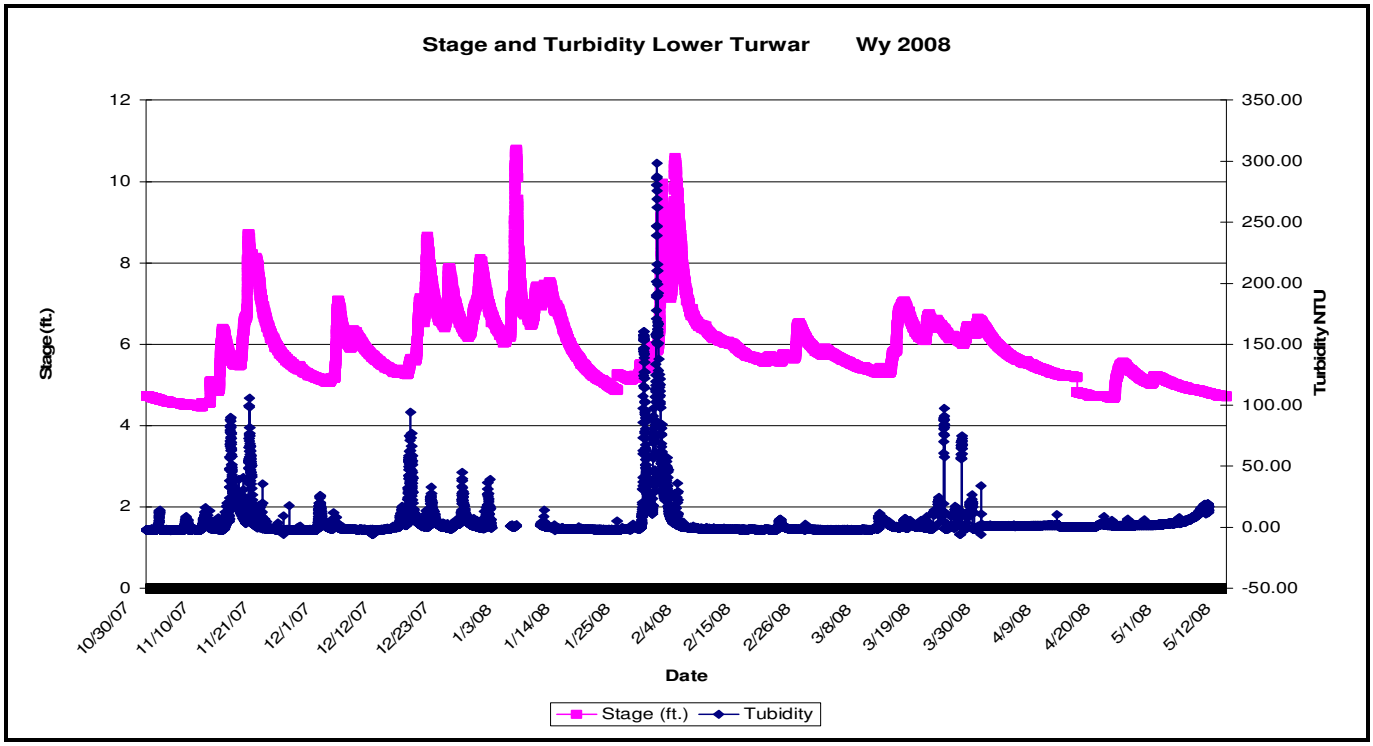


Figure 15. Stage height and turbidity values Water Year 2008.

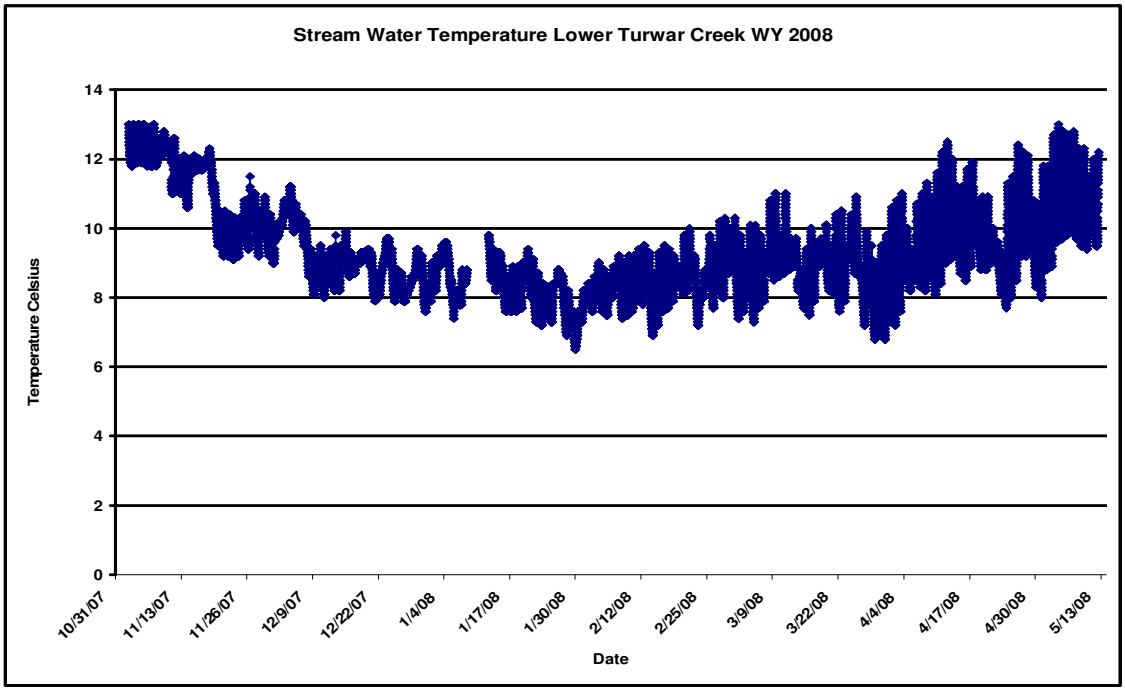


Figure 16. Water temperature in degrees Celsius, Lower Turwar Creek, Water Year 2008.

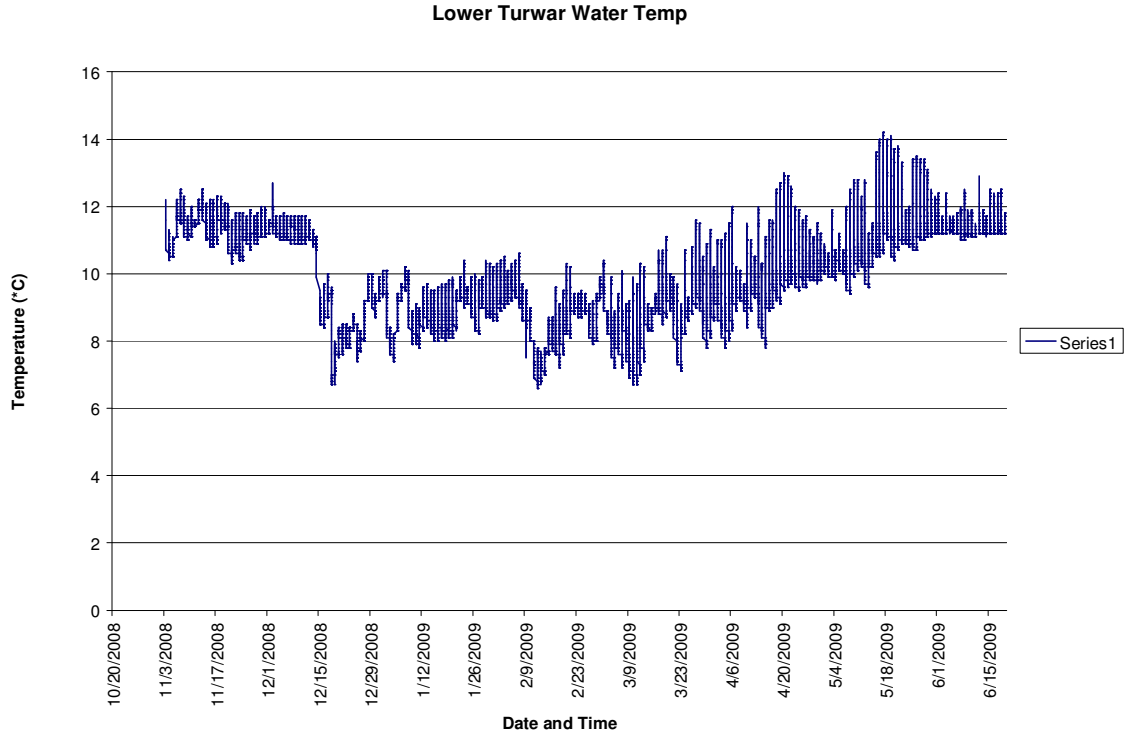


Figure 17. Water temperature in degrees Celsius, Lower Turwar Creek, Water Year 2009.

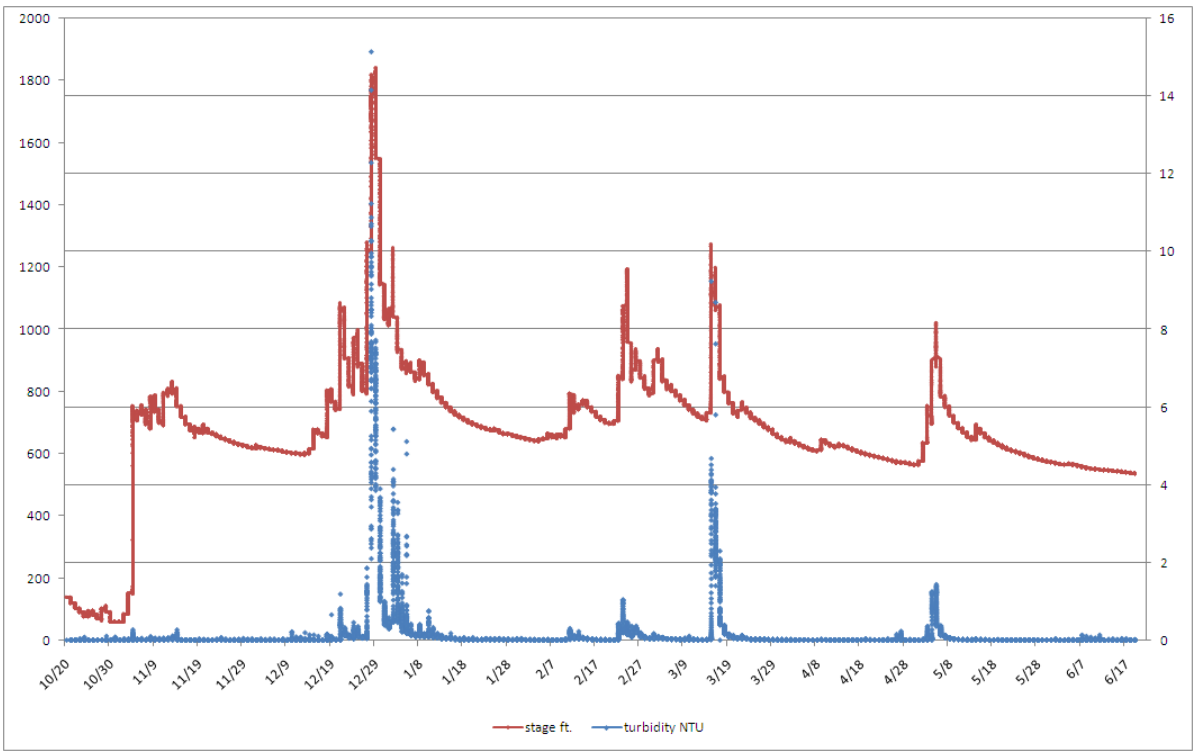


Figure 18 Stage height and turbidity values Water Year 2009

Table 1. Suspended sediment concentrations (mg/L) results, Lower Turwar Creek, Water Year 2008.

Bottle #	Date Sampled	Begin Time	End Time	DIS or Grab	SSC mg/l	Gage Height	Lab Turb1 NTU	Lab Turb2 NTU	Lab Turb3 NTU	ProbeTurbidity NTU
LTURWAR_010508A1-A3	1/5/08	13:55	14:15	DIS	68.9	9.08	5.4	5.6	4.7	11.10 (avg)
LTURWAR013108A2+A3	1/31/08	11:49	12:10	DIS	679	9.46	75	75	n/a	146
LTURWAR013108B1-B3	1/31/08	13:15	13:26	DIS	717	9.48	100	100	110	153
LTURWAR013108C1-C3	1/31/08	12:32	12:46	DIS	629	9.63	110	100	36	158
LTURWAR013108D1-D3	1/31/08	13:42	13:50	DIS	628	9.66	100	100	100	154
LTURWAR013108E1-E3	1/31/08	14:05	14:15	DIS	581	9.66	95	95	90	154
LTURWAR013108F1-F3	1/31/08	14:31	14:42	DIS	790	9.76	95	95	100	144 (avg)

Table 2. Suspended sediment concentrations (mg/L) results. Lower Turwar Creek Water Year 2009

Bottle #	Date Sampled	Begin Time	End Time	DIS or Grab	SSC1 mg/l	Gage Height	Turb1 NTU	Turb2 NTU	Turb3 NTU	Turb4 NTU	Turb5 NTU
LTURWAR_031509	3/15/09	19:47	20:23	dis	1432	9.83	498	527	550	534	
LTURWAR_031509	3/15/09	19:47	20:23	box	1203	9.83	542				
LTURWAR_031609	3/16/09	13:53	14:13	dis	798	10.94	347	357	354	354	347
LTURWAR_031609	3/16/09	13:53	14:13	box	764	10.94	343				
LTURWAR_031709	3/17/09	16:17	16:32	box	202	8.23	63				
LTURWAR_031709	3/17/09	16:17	16:32	dis	187	8.23	61.6	68.3	61.9	64.6	60
LTURWAR_031809	3/18/09	14:44	15:00	box	69.8	7.22	21.9				
LTURWAR_031809	3/18/09	14:44	15:00	dis	89.2	7.22	19.9	20.9	18.3	17.4	

SSC=Suspended Sediment Concentration DIS=Depth Integrated Sample box=box sample

3. b. <u>Lower Turwar Creek Macroinvertebrate Sampling</u>

Table 2. Lower Turwar Creek Macroinvertebrate Metrics 2006 to 2009

Sample I.D.	Sample Date	Total # of Specimens	Taxa Richness	EPT Taxa Richness	Sensitive EPT Index (%)	% Dominant Taxon	Tolerance Value	Shannon's DI	Est Relative Abundance
Lower Turwar 2006	4/28/2006	502	26	17	27	64	3.82	1.51	2458
Lower Turwar 2007	5/7/2007	505	30	21	39.41	40.79	3.70	2.24	2621
Lower Turwar 2008	4/30/2008	514	37	25	36.38	33.46	3.77	2.42	1392
Lower Turwar 2009	4/20/2009	515	31	20	14.95	70.1	5.02	1.47	2413

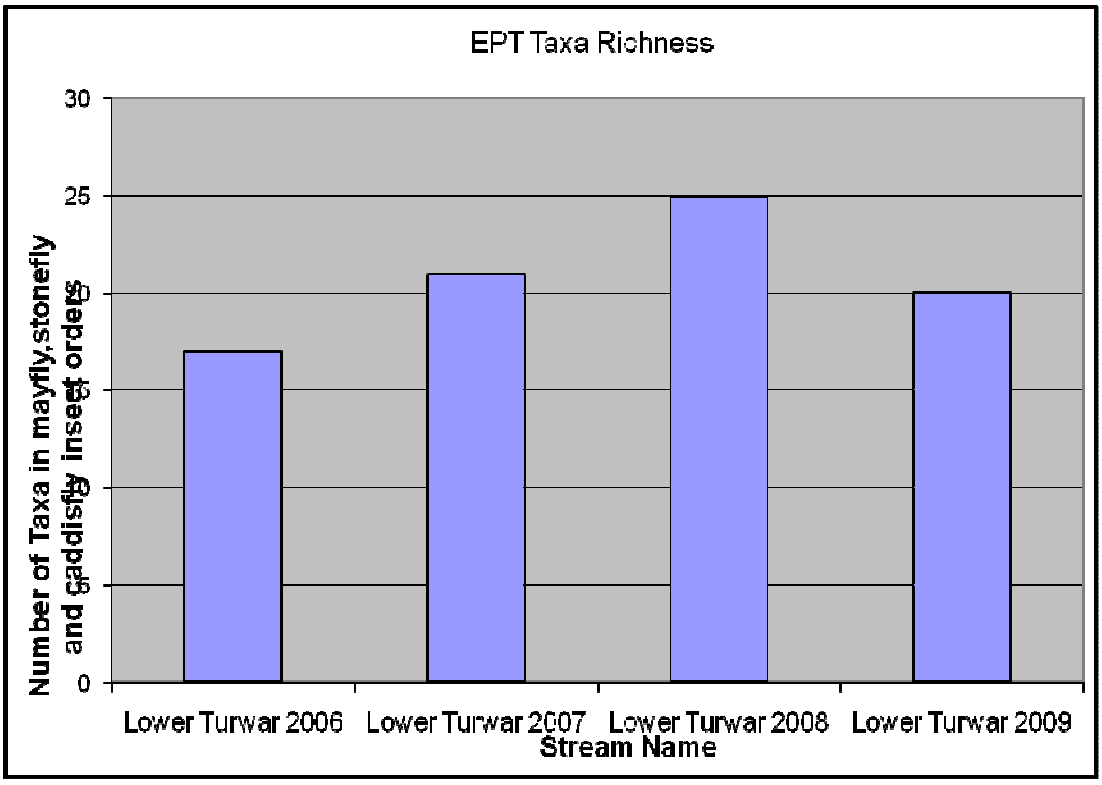


Figure 19. EPT Taxa Richness, Lower Turwar Creek, 2006 to 2009.

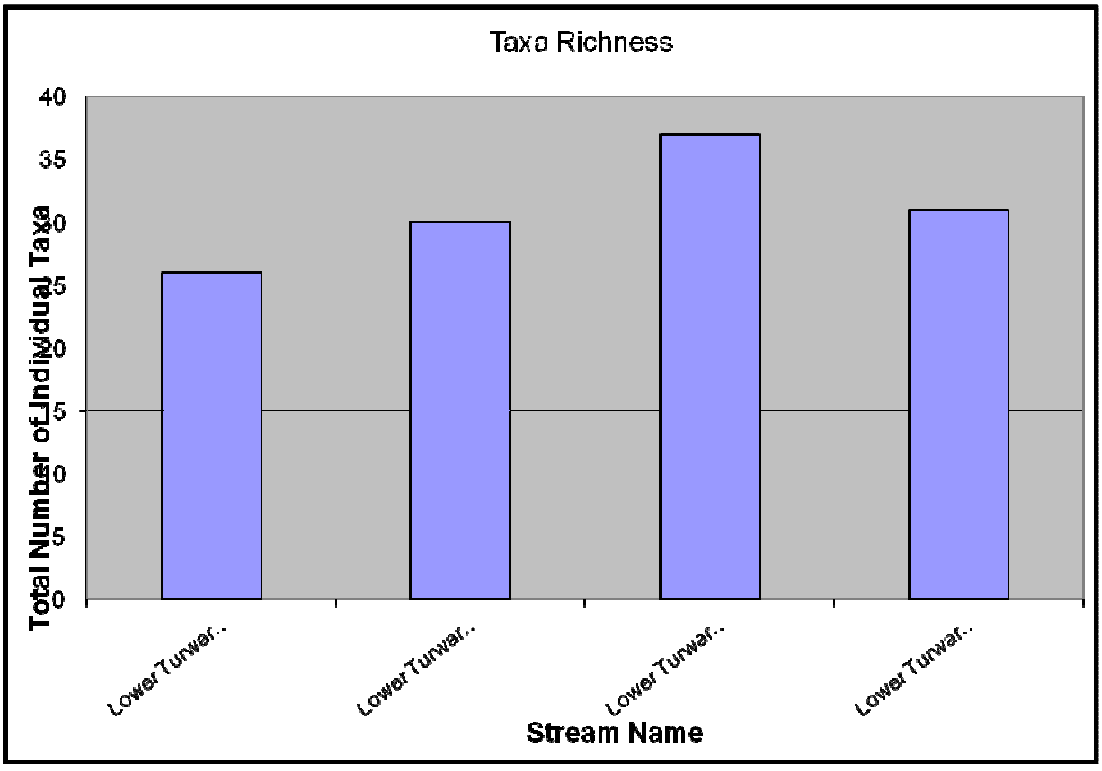


Figure 20. Taxa Richness, Lower Turwar Creek, 2006 to 2009.

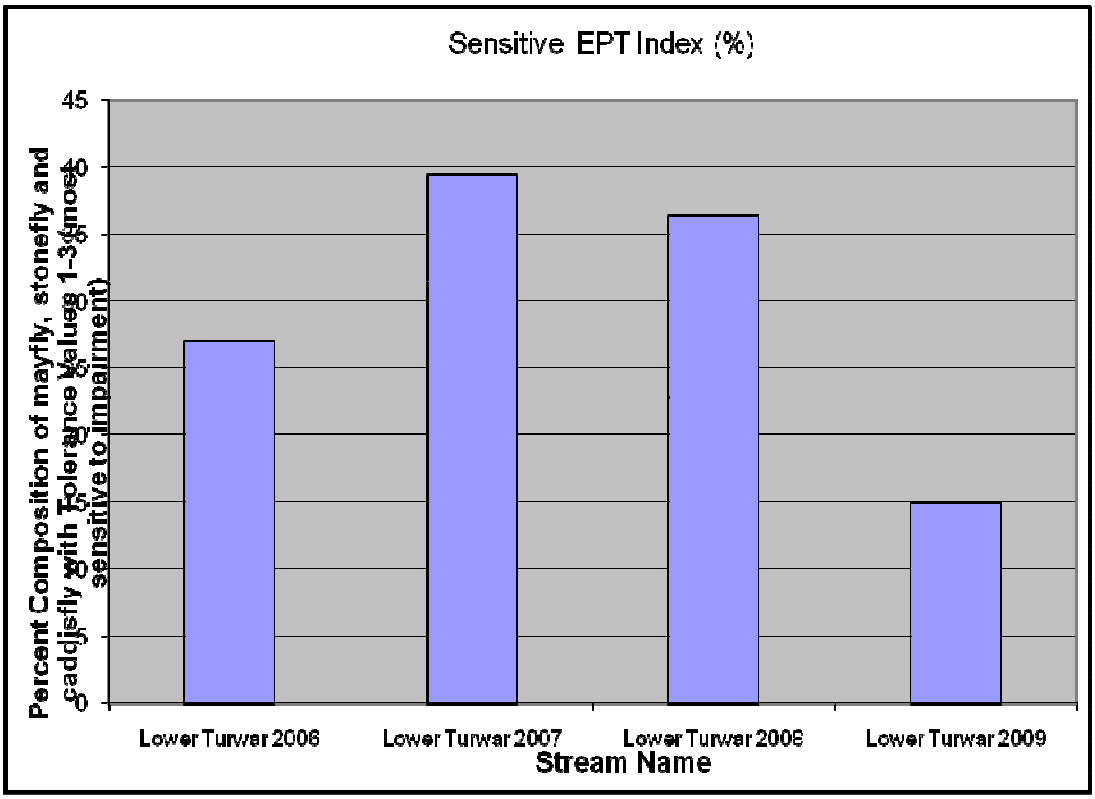


Figure 21. Percent Sensitive EPT Taxa, Lower Turwar Creek, 2006 to 2009.

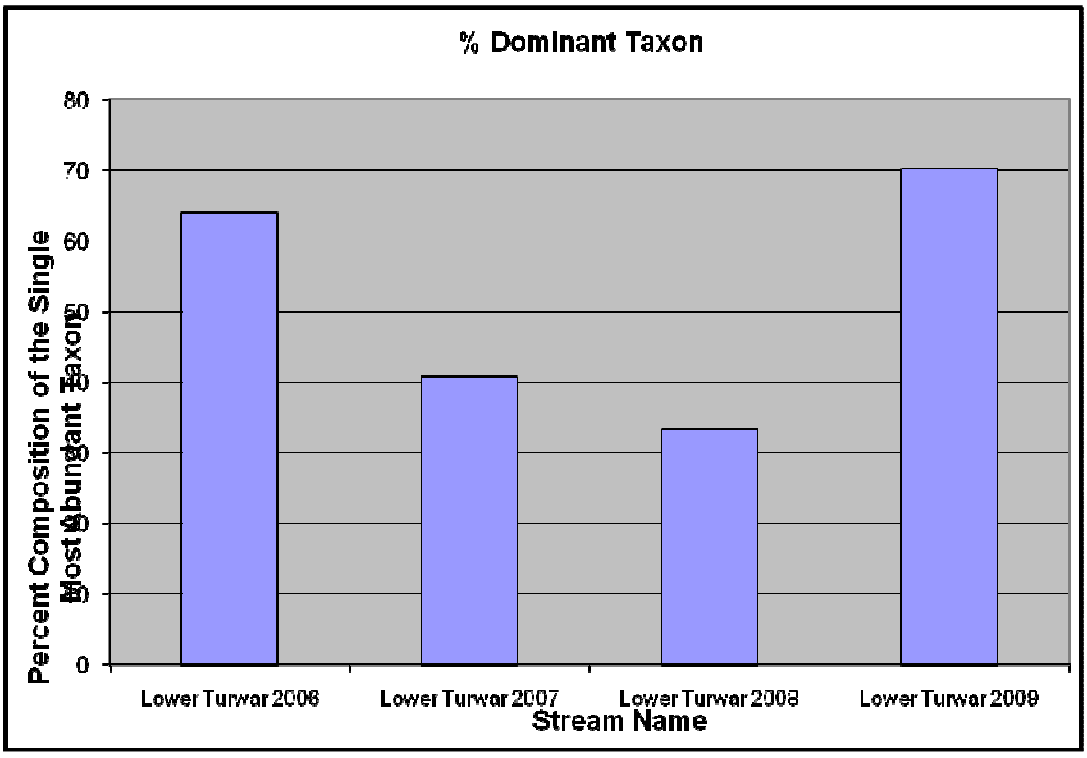


Figure 22. Percent Dominant Taxon, Lower Turwar Creek, 2006 to 2009.

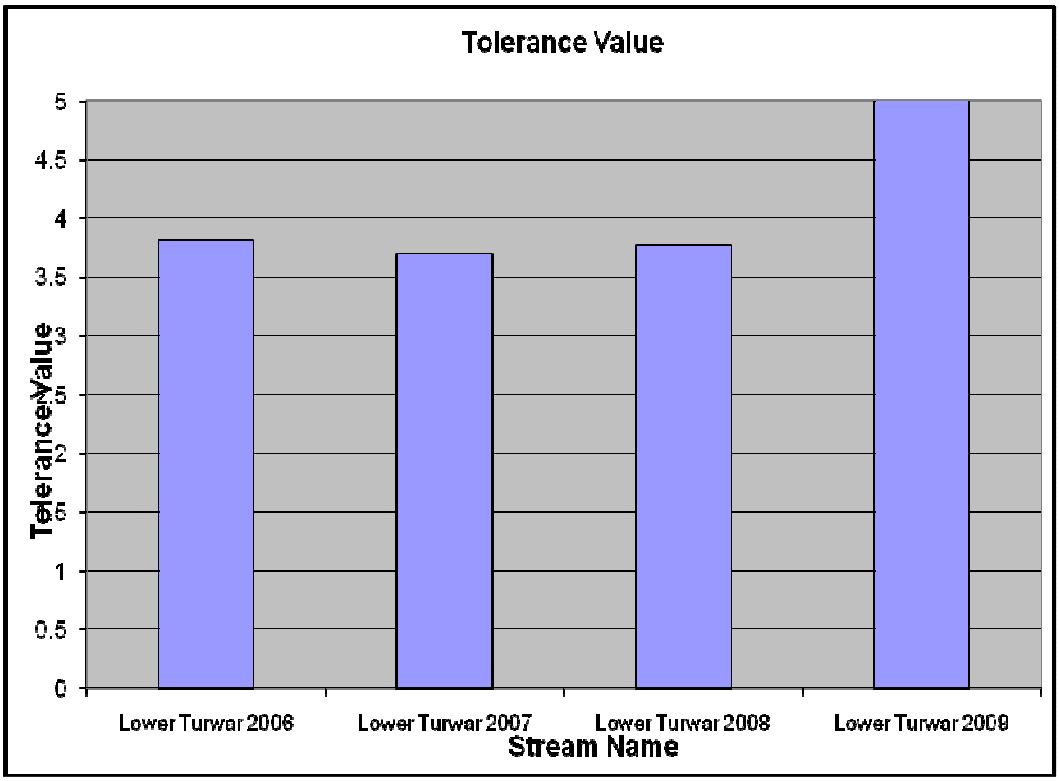


Figure 23. Average Tolerance Value for all taxa recorded, Lower Turwar Creek, 2006 to 2009.

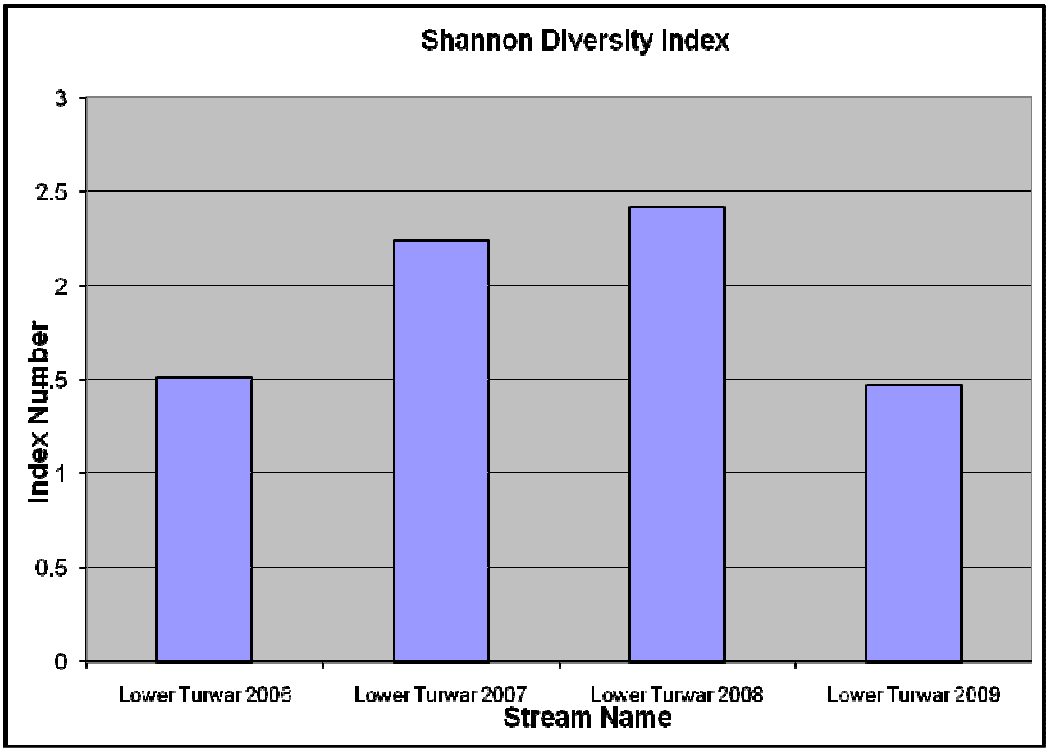


Figure 24. Shannon Diversity Index, Lower Turwar Creek, 2006 to 2008.

Table 3. North Coast Index of Biological Integrity (NC-IBI) Metric Values and Final Score, Lower Turwar Creek, 2006 to 2009.

Date	EPT Richness	Coleoptera Richness	Diptera Richness	% Intolerant	% non-Gastropod Scraper	% Predator	% Shredder	% non-Insect	NC-IBI Score Total
4/28/2006	17	1	3	27	10	12	0	9	45
5//2007	21	2	4	35	16	12	7	10	61.25
4/30/2008	25	2	5	37	10	23	11	14	70
4/20/2009	20	3	3	16	11	7	3	16	48.75

Table 4. Key to NC-IBI final metric scores.

Total Metric Score	**Value**
0-20	**very poor**
21-40	**poor**
41-60	**fair**
61-80	**good**
81-100	**very good**
>52	**"unimpaired"**

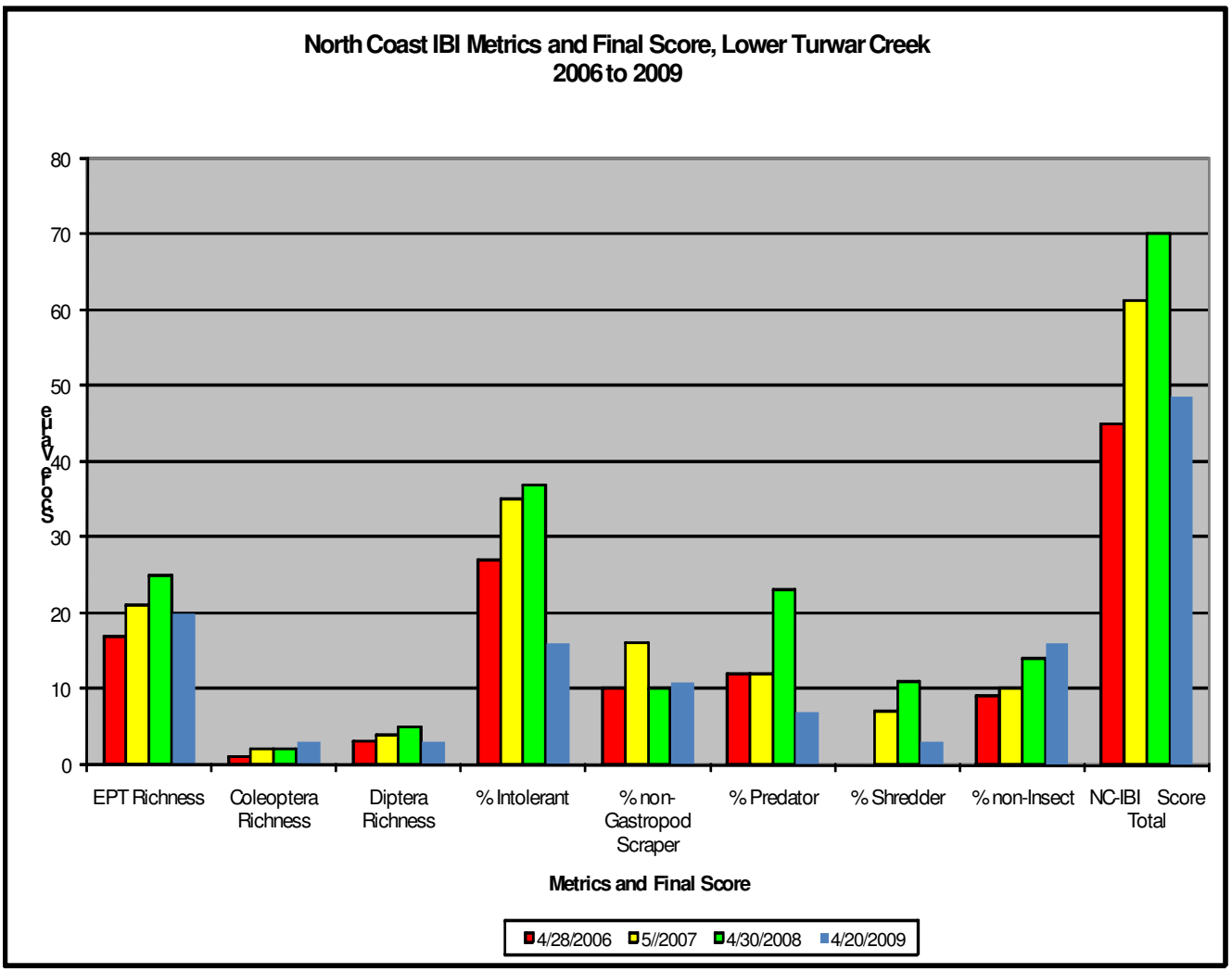


Figure 25. North Coast Index of Biological Integrity (NC-IBI) Metric Values and Final Score, Lower Turwar Creek, 2006 to 2009.

4. Discussion

4. a. Lower Turwar Creek Monitoring Station

The continuous monitoring station at Lower Turwar Creek collected stage height, water temperature and turbidity data at a 15 minute interval from late October/early November to mid May in Water Year 2008 and mid October to late June in 2009 In general the monitoring station performed well with few malfunctions. On December 28, 2008 during a large storm event, the orifice line was pulled away from the attached rip rap, causing a 3.42' shift in the end of the orifice line. Data after that date was heavily scrutinized and 98% of it still passed our quality assurance standards. Erroneous data due to equipment malfunction, operator error or equipment out of water was removed prior to reporting as part of the internal data validation process.

The rating curve for stage height in feet and stream discharge in cubic feet per second (cfs) had a strong coorelation with a R^2 value of 0.9261 (Figure 12). Measured flows ranged from 13 cfs to 3666 cfs. The rating curve slope equation was used to equate discharge values for the entire record in Water Year 2008 to present 2009 to develop the stream hydrograph (see figure 12). Discharge values exceeding twice the measured flow (7332 cfs) are to be considered estimates. Efforts will be made in the future to capture additional high flow events to increase the confidence in the flows that exceed 7332 cfs. The flow taken on that date seems to be an outlier, but in reality it is just that the rating curve generated by Microsoft Excel© does not have the capabilities to generate a highly accurate representation of this relationship during really big flow events. (See figure 12) YTEP purchased Aquarius© software in mid 2009. This software is a highly specialized and powerful tool in analyzing stream hydrology data. It is going to allow us to really analyze and better understand the dynamics occurring in Lower Turwar and all other streams monitored. This tool is used by USGS to create all of their rating curves for over 7,000 streams and rivers. We will be in the process of re-assessing all of our rating curves in the near future.

The highest flow event of the water year occurred on 3/16/2009 the stage height was 10.99 feet, discharge was 3666 cfs. (See figure 13) This figure shows that the stream exceeded its normal channel banks and spread to bank full width. This causes the discharge to continue to be higher, but stage does not rise as quickly due to the increased area covered. The flow was taken using our bridge crane with a Price AA® flow meter. The lowest estimated flow in Lower Turwar Creek was 13 cfs and occurred at the beginning of the water year on 11/9/07.

Turbidity peaks concurred with storm events during the water year (Figures 15 and 18). The highest turbidity measurement recorded was 1891 NTU during a storm that occurred on 12/28/2009. Although the DTS-12 turbidity probe is only highly accurate up to 1600 NTU's (according to manufacturer specifications) we trusted the 1891 NTU measurement due to the intensity of the storm event and the amount of sediment moving through the Lower Turwar system thoughout this event. Water temperatures throughout the water year 2008 ranged from 6.5 to 13.0 degrees Celsius (Figure 15). The maximum water temperature of 13.0 degrees Celsius occurred in November and May. The minimum water temperature was 6.5 degrees Celsius and occurred on January 30, 2008.

Suspended sediment samples were collected during storm events on January 5 and January 31, 2008. The storm on 1/05/08 was the first sizable storm during the water year. One set of samples were collected and it occurred on the descending limb of the hydrograph, the suspended sediment concentration (SSC) was 68.9 mg/L (Table 2). The second storm was sampled during the ascending limb of the hydrograph and SSC ranged between 581 - 791 mg/L for the six sets of composite samples that were collected (Table 2). In Water Year 2009 there were only 2 large events again. The first and largest happened in December of 2008. YTEP lost equipment in the stream from large debris and unseen submerged objects and were unable to continue to monitor this event. The next event was between 3/15/09-3/18/09. (see table 2) All dates were sampled. The 15th was ascending and 16th, 17th, and 18th were all descending. This data set will prove to be very valuable to YTEP to help develop the box and depth integrated sample relationship.

Comparing 2008 to 2009 SSC and turbidity results are limited to precise comparison for a couple of reasons. In early spring of 2009 YTEP had a consultant (Cort Pryor of Graham Matthews and Associates) accompany YTEP in the field to audit field methods and showed a need for small refinements in data collection of SSC. Due to the results of the audit, 2008 SSC results may be lower than actual conditions. In conjunction with this knowledge and the limited 2 years of data YTEP feels it is too presumptuous to elaborate on SSC and turbidity trends in the Lower Turwar Creek watershed. Further refinements and more data collection will ultimately give YTEP more confidence in collecting and analyzing data. In the years to come YTEP should have a clearer understanding of the SSC and turbidity trends occurring in Lower Turwar Creek.

4. b. Lower Turwar Creek Macroinvertebrate Sampling

Macroinvertebrate sampling results were combined for the years samples were collected in Lower Turwar Creek from 2006 through 2009. Figures 19 to 24 report popular metrics that are commonly reported in YTEP's taxonomic results from the lab. EPT Taxa richness and taxa richness (figure 16 and 17) indicate that diversity of taxa has increased from 2006 to 2008, and a slight decline in 2009 .This trend is also confirmed by Figure 19 which illustrates that the percentage of a single taxa present in samples has decreased from 2006 to 2008 and increase in 2009 It appears that species abundance is also increasing as illustrated in figure 21 in which the Shannon Diversity Index increased from 2006 to 2008. A higher Shannon's diversity index value is representative of a more diverse community.

The 2006 to 2009 macroinvertebrate sampling results were used to generate metrics used in the North Coast index of biological integrity (NC-IBI) developed by the Department of Fish and Game. These results are reported in table 3 and in Figure 22. The NC-IBI metrics and final scores indicate that the macroinvertebrate assemblages have improved from 2006 to 2008. In 2006 the final NC-IBI score was 45, in 2007 it was 61.25 in 2008 it was 70, and 2009 it was 48.75. The NC-IBI defines a score of less than 52 to be in the "impaired" range. Following, the 2006 sample event results in 2007 and 2008 exceeded the value of 60. Therefore, the NC-IBI scores based on macroinvertebrate samples indicate that the stream health of Lower Turwar Creek has moved from being "fair" to "good". In 2009 there was a significant drop not only in the NC-IBI score but in the overall diversity of the population sampled. Out of a sub sample of 515 specimens 361 were Chironomidae. It is difficult to say why this is but a few ideas are; that there was a large storm event between March 15th and the 18th. This event was the 2nd largest of the year for Lower Turwar. (See figure 17) Even though we followed SWAMP protocol and waited 30 days or longer before sampling, the event may have created optimal conditions for a proliferation of the Chironomidae. This large number of Chironomidae contributes to the lower numbers of other taxa, and may be misleading to say that the stream habitat and diversity have changed for the worse. Further macroinvertabrate sampling in the next few years will give us a better understanding of the trends occurring in Lower Turwar Creek.

It is likely that the instream habitat restoration projects implemented by the Yurok Tribe Fisheries Program have influenced this stream health improvement trend. The restoration

treatments that were designed to provide reduction of sediment delivery, increased channel and streambank stability, increased habitat complexity, improved large woody debris recruitment and self-sustaining riparian forests have improved habitat for macrioinvertebrates and have provided additional trophic levels to improve diversity.