Upper Carson River Watershed

2020 Water Quality Objectives Report

Volunteer River Monitoring Program
Alpine Watershed Group
www.alpinewatershedgroup.org

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Summary

In 2020, Alpine Watershed Group (AWG) volunteers collected their seventeenth year of water quality data on the headwaters of the Carson River watershed. Data from these observations give us the big picture of overall ambient water quality conditions for this watershed. The water quality parameters measured for our river monitoring program are stream temperature, dissolved oxygen, pH, turbidity, and conductivity/total dissolved solids. Overall, 88% of the measurements collected in 2020 meet water quality objectives. Compared to all years, only stream temperature shows a decline in the amount of measurements that met objectives. This report provides an overview of our river monitoring program, an analysis of our 2020 data, and a discussion about the variables that influence, and are influenced by, the parameters that we measure.

Water Quality Parameter	Objective	% Met in 2020	% Met in All Years
Stream Temperature	Less than 12.0℃*	72%	76%
Dissolved Oxygen	Greater than 7.37 mg/L*	100%	91%
pH	Between 7.31 and 8.31*	78%	74%
Turbidity	WF < 2 NTU EF < 15 NTU	100% 100%	79% 89%
TDS	WF < 55 ppm Paynesville < 70 ppm EF < 80 ppm	75% 100% 75%	N/A

*Normal conditions used to determine the specific values for the water quality objectives for stream temperature, dissolved oxygen, and pH are estimated averages based on valid records, as specified in AWG's Quality Assurance Project Plan's (QAPP, Schembri, 2007) field measurement precision standards, from AWG's 2005 to 2020 period of record (calculations outlined in the Appendix A).

Introduction

The headwaters of the eastern Sierra Nevada mountain range in Alpine County, California, feed into two primary tributaries: the East Fork and West Fork Carson River. They support important ecosystem services such as fish and wildlife habitat, clean drinking water, and recreation activities. These tributaries converge in Nevada near Genoa, and the Carson River eventually ends in what is known as the Carson Sink on the eastern side of Fallon, Nevada.
With a small population of around 1,100 permanent residents, Alpine County waterways do not have the same threats that urbanized riparian areas have. They appear pristine in comparison; however, historical degradation from mining, grazing, logging, and construction has led to impaired sections of our rivers and creeks.

With additional threats—such as impacts from climate change—continued monitoring of our streams and rivers is imperative to support and inform ongoing and future stewardship practices. That is, monitoring can help inform best practices for mitigation, restoration, and preservation activities at local scales, as well as inform watershed-health outreach, education, and planning needs. The general purpose of AWG's river monitoring program is to observe long-term trends in water quality conditions and to give an overall picture of watershed health for the Upper Carson River headwaters. While the data that is collected is limited by the frequency that it is collected, it serves well to provide overall seasonal conditions of our waters.

Water quality objectives for ambient surface waters—such as streams and rivers—are defined differently depending on where these waterbodies are located and what they are used for. That is, here in Alpine County, our water quality objectives for the headwaters of the Carson River are different than the objectives set for downstream users. The objectives for the Upper Carson River watershed are set by the Lahontan Regional Water Quality Control Board. They are outlined in their *Water Quality Control Plan*—also referred to as the *Lahontan Basin Plan*—and are based on their beneficial uses (California Regional Water Quality Control Board, 1995). Impaired streams and rivers are defined as such when they are not meeting water quality objectives and standards, and restoration or remediation may be necessary in order to restore conditions to a healthy state (Federal Water Pollution Control Act, 2002). The West Fork Carson and the East Fork Carson have different historical impacts, beneficial uses, and normal conditions, resulting in different water quality objectives for certain parameters.

All water quality objectives for the parameters discussed in this report are outlined in the *Lahontan Basin Plan*; however, the plan utilizes "normal" and/or "natural" conditions to define objectives, but it doesn't go further to quantify the values for "normal" and/or "natural" conditions. Presently, the Lahontan Regional Water Quality Control Board doesn't have a defined method for determining "normal" and/or "natural" conditions for these waters. For the purpose of this report, when "normal" and/or "natural" conditions are used in water quality objective definitions, these values are estimated based on averages from AWG's 2005 to 2020 water quality data. These parameters include stream temperature, dissolved oxygen, and pH.

The calculations used to determine these objectives are further defined in Appendix A of this report. Values for turbidity and total dissolved solids water quality objectives are quantified in the *Water Quality Control Plan*.

AWG staff and Restoration and Monitoring Committee (RMC) have spent the last two years looking more closely at our full period of water quality records, dating from 2004 to present, to establish more critical quality assurance procedures and reevaluate our baseline data targets which we compare our data to and report out on. AWG's *2019 Water Quality Objectives Report* used the full period of record (2004-2019) to estimate objective values. However, in June 2021, the RMC with AWG staff guidance chose to use valid records only from 2005 to 2020 as the fixed period to establish normal conditions for this and subsequent reports moving forward. This new time period was selected due to covering the majority of AWG's dataset while also including variable water years such as the 2014 drought and 2017 high-water years. The 2004 data was thrown out due to not being a complete year of data. Beyond changes to the time period, valid records were more closely examined by comparing our dataset to AWG's QAPP (Schembri, 2007) Table 3: Data quality objectives for field measurements. Table 3, found on page 12 of the QAPP, notes the precision standards used to define each parameter's acceptable field measurement range. If each record did not have three measurements and meet the respective precision standards for field measurement range, then it was not considered valid and therefore was not used to calculate "normal conditions." The new approach of comparing AWG data to a fixed period will allow for easier tracking of trends over time.

Data and Methods

Water quality data used for this analysis are collected by volunteer monitors four times a year at eight locations in the Upper Carson River watershed. These sampling sites can be located using the map in Figure 1. They are: #1 West Fork-Woodfords (WF-WDFD), #2 Hot Springs Creek-Grover Hot Springs (HSC-GHS), #3 East Fork-Hangman's Bridge (EF-HANG), #4 West Fork-Paynesville (WF-PNSV), #5 Markleeville Creek-Library (MVC-LIB), #6 West Fork-Picketts Junction (WF-PKT), #8 Silver Creek-Highway 4 (SVC-HWY4), and #9 Red Lake Creek-Blue Lakes Road (RLC-BLR).

Figure 1. Map of Alpine Watershed Group's river monitoring locations in the Upper Carson River watershed

Typically, sampling takes place during the week before and including the second Saturday of March, June, August, and September (but some of our data were collected in December until 2010). Staff follow monitoring protocols outlined in AWG's QAPP, which was approved by the California State Water Resources Control Board. Volunteer monitors measure three samples for each of the five water quality parameters as well as air temperature. AWG staff input collected data into our internal database, and we also report it to the California Environmental Data Exchange Network (CEDEN). There it is combined with additional data sources for our county and made available to the public (California Environmental Data Exchange Network, 2020).

For this report, measurements for each parameter at each sampling site are averaged and graphed over time. The smaller graphs display results from our 2020 monitoring season, and the larger graphs display results for our full period of record, which dates back to 2004. Each point depicted in the graphs represents the average of the three measurements for each site during each sampling month. Results are reported by water quality parameter. All graphs include the targeted water quality objective for each parameter labeled as either a maximum or minimum. Normal conditions for stream temperature, dissolved oxygen, and pH are estimated based on valid records, as specified in our QAPP's field measurement precision standards, from AWG's 2005 to 2020 water quality dataset.

Results and Discussion

Stream Temperature

Stream temperature is a significant variable influencing water quality in ambient surface waters as it is related to nearly all other parameters that we measure. The graphs in Figures 2 and 3 report stream temperature as a function of time. The seasonal climate of the Upper Carson River watershed is clearly defined here, as stream temperature measurements are at their coldest during March and at their warmest during August. Looking at the graph in Figure 3, we can see the difference in stream temperature over multiple years. For example, it is clear that stream temperature measurements were at their highest during 2008, 2013, and 2015 compared to other years.

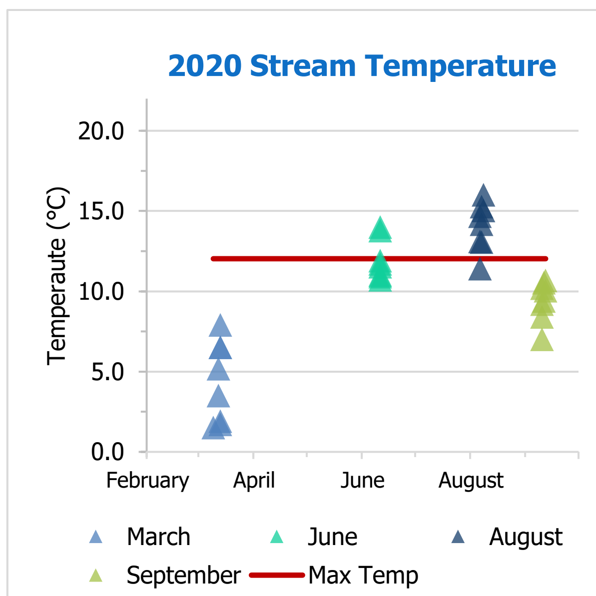

Figure 2. 2020 stream temperature measurements for the Upper Carson River watershed

Most of the sites that we measure in the Upper Carson River watershed have waters that are designated as "cold" waters as part of their beneficial uses (California Regional Water Quality Control Board, 1995). Because of this, the water quality objectives at these sites are more stringent than waters that don't have this designation. More information about the beneficial uses of the Upper Carson River watershed can be found in Chapter 2 of the *Lahontan Basin Plan*. A cold water designation typically means these waters support a function—such as providing ecological habitat for important species—that requires minimal change to the natural conditions of the water body.

The objective set for stream temperature by the Lahontan Regional Water Control Board states on page 3 - 6, "For waters designated COLD, the temperature shall not be altered." The *Lahontan Basin Plan* doesn't give quantified normal temperature values for the Upper Carson River waters, so the values used to determine our objective are estimated. Previously, AWG established a maximum of 19℃ as the objective for this parameter, as this is the maximum temperature that can support healthy brown trout habitat (Elliot & Hurley, 2001; Vance, 2018). This value, however, is significantly higher than our normal water temperature conditions, so it doesn't reflect objectives outlined in the Basin Plan.

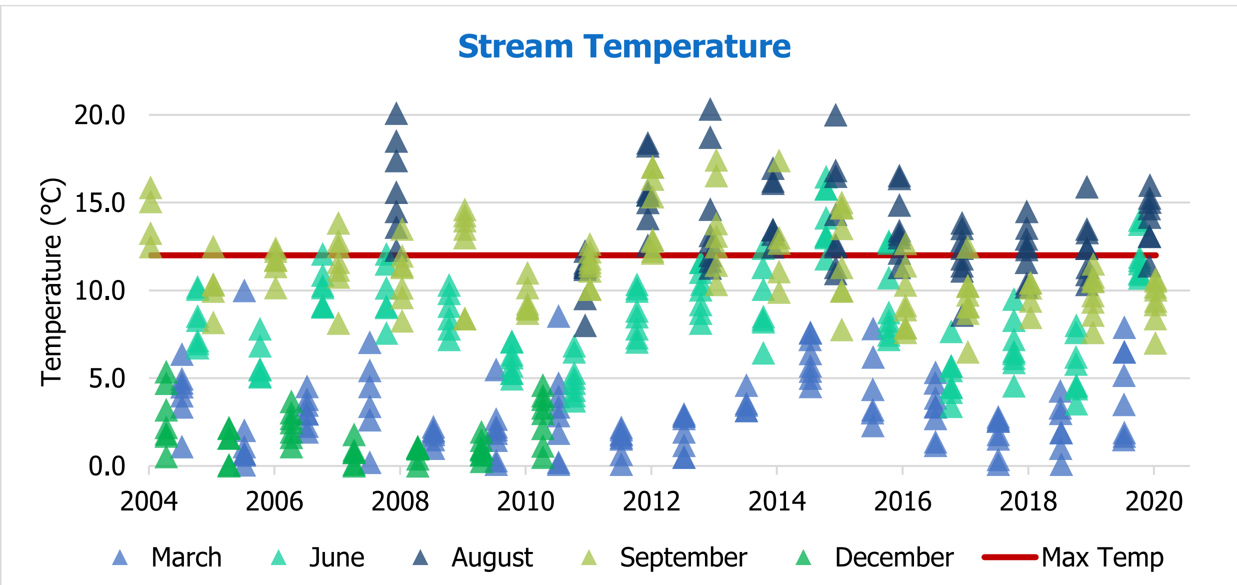

Figure 3. Stream temperature measurements for the Upper Carson River watershed

To make our objective in accordance with the *Lahontan Basin Plan* for our region, we estimate a normal temperature based on valid records from our 2005-2020 data. For this estimate, we only use data that was collected in August and September to determine our maximum normal temperature, as those are the warmest months of the year. The average maximum stream temperature from all of our valid measurements between 2005 and 2020 is 12.0℃ giving us our objective for this water quality parameter (Appendix A). Under this water quality objective, 23 out of our 32 (71.9%) records taken in 2020 fall within this designation, and 380 out of 498 (76.3%) measurements in our full period of record (2004-2019) meet this objective.

Dissolved Oxygen

Dissolved oxygen (DO) is an important water quality parameter because many aquatic organisms require it to survive. Fish, for example, absorb it through their gills in order to "breathe" and get oxygen to their bodies. DO concentration in water has an inverse relationship with water temperature: as water temperature increases, DO concentration decreases. This relationship can be seen by comparing Figure 3 (above) with Figure 5 (below).

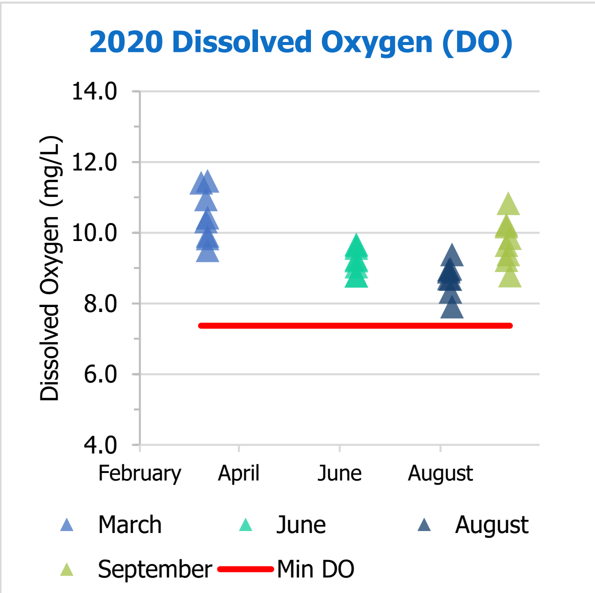

Figure 4. 2020 dissolved oxygen concentration measurements for the Upper Carson River watershed

For the West Fork and East Fork Carson River, the *Lahontan Basin Plan* states on pages 3 - 9 and 3 - 10, "The dissolved oxygen concentration shall not be depressed by more than 10 percent, below 80 percent saturation, or below 7.0 mg/L at any time, whichever is more restrictive." In order to determine the objective level that is most restrictive, we first estimate the normal minimum DO concentration for our waters. Data collected in August and September from 2005 to 2020 are used to estimate an average DO concentration of 8.19 mg/L. A 10 percent depression of this value yields an objective value of 7.37 mg/L minimum DO concentration, which is more restrictive than 7.0 mg/L.

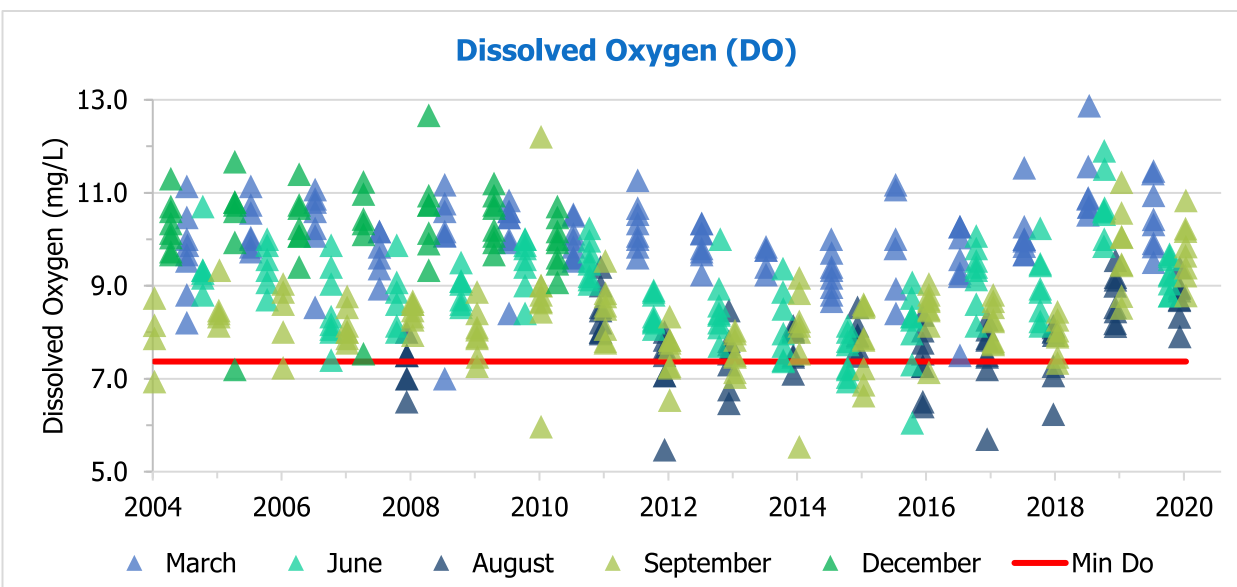

Figure 5. Dissolved oxygen concentration measurements for the Upper Carson River watershed

In order to calculate the DO at 80% saturation, we use the average maximum water temperature of 12.0℃ calculated from our dataset and the average barometric pressure at 6,000-feet elevation above sea level, which is 81.2 kilopascals or kPa. Inputting these values into the online tool DOTABLES, created and maintained by the U.S. Geological Survey (USGS), yields a DO value of 8.61 mg/L at 100% saturation, and 6.89 mg/L at 80% saturation (United States Geological Survey, 2018). The most restrictive value calculated for our minimum DO concentration is 7.37 mg/L (10% depression of our estimated normal minimum DO) (Appendix A).

Utilizing our estimated objective of 7.37 mg/L minimum concentration, we found that 100.0% (32 out of 32) of our records in 2020 meet our dissolved oxygen objective, and 90.9% (452 out of 497) of records from 2004 to 2020 meet water quality objectives for this region.

pH

The pH value of water is a relative measurement of its hydrogen ion composition. The concentration of hydrogen ions is essentially what determines the acidity, or pH, of water bodies. When there are more hydrogen ions than hydroxide ions (or another ion that can bond with hydrogen ions), then water will have a pH below 7 indicating that it is acidic. When there are more hydroxide ions than hydrogen ions, the pH will be above 7 indicating it is a basic solution.

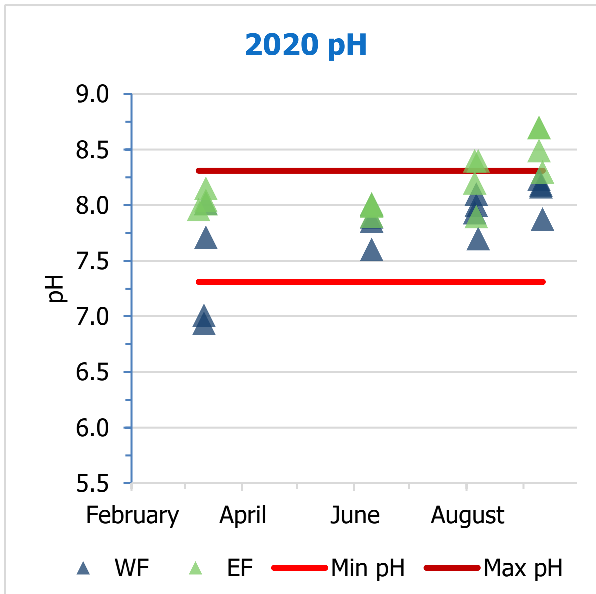

Figure 6. 2020 pH measurements for the Upper Carson River watershed

Monitoring this parameter is important for a variety of reasons. Aquatic organisms typically require a stable range of pH levels to survive. The acidity of water also affects the solubility of and chemical reactions between minerals that water comes into contact with. Depending on local geological conditions, changes in pH can catalyze reactions resulting in a different chemical makeup of the system and impact habitat conditions. Figures 6 and 7 give the full results from our pH monitoring measurements.

The *Lahontan Basin Plan* states on page 3 - 5 that, "In fresh waters with designated beneficial uses of COLD or WARM, changes in normal ambient pH levels shall not exceed 0.5 pH units." In order to estimate "normal ambient pH levels," we used the average pH value from all valid records in our period of record spanning from 2005 to 2020. This estimated normal pH is 7.81, so the resulting range used as our objective is 7.31 to 8.31 (Appendix A). Utilizing this range as our water quality objective for pH, we find that 78.1% (25 out of 32) of our pH records in 2020 meet objectives, and 74.1% (369 out of 498) of records from the entire period meet our objectives.

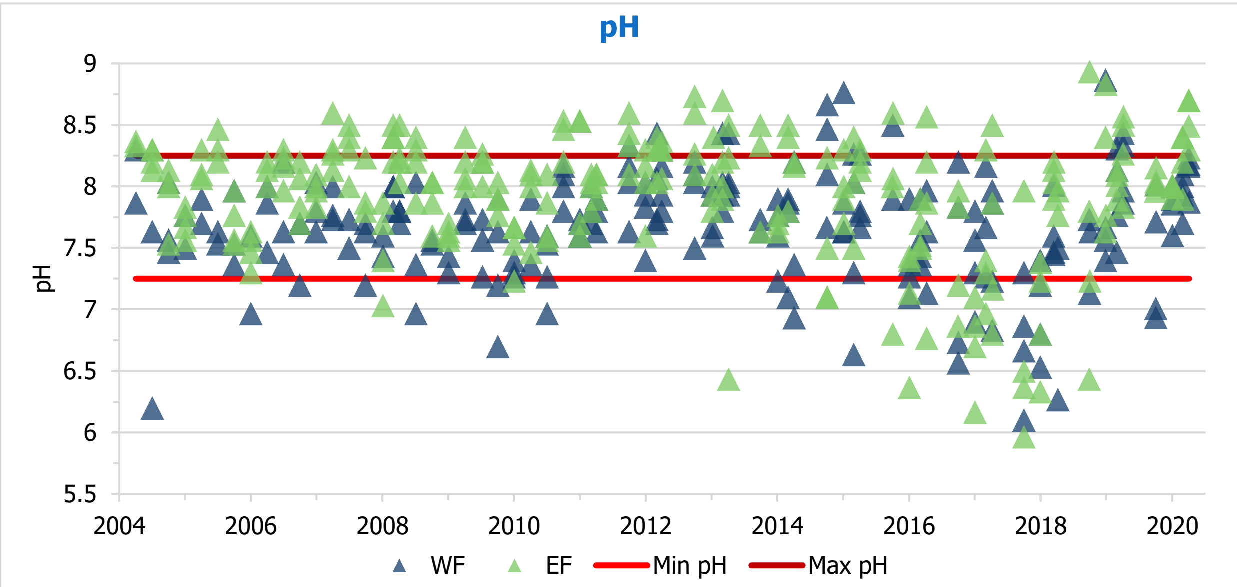

Figure 7. pH measurements for the Upper Carson River watershed

Turbidity

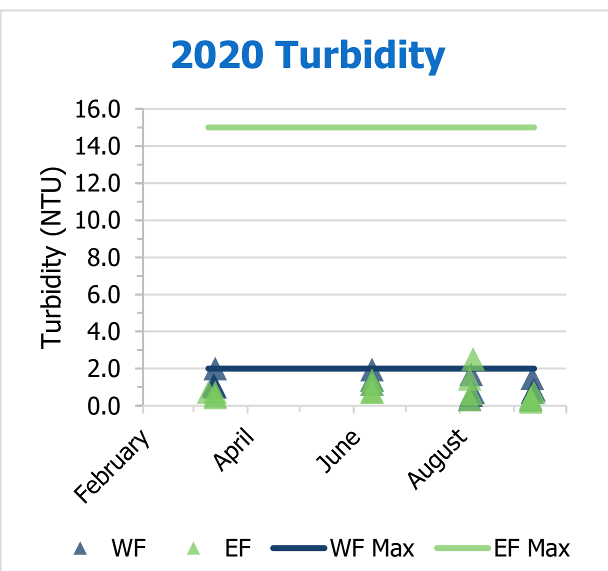

Figure 8. 2020 turbidity measurements for the Upper Carson River watershed

Turbidity is a measurement of water clarity, and it is measured in nephelometric turbidity units or NTUs. This tells us information about the ability of light to penetrate a body of water. If there is a high concentration of suspended solids, then light will be scattered giving a high turbidity value. If there are low concentrations of suspended solids, like in pure water, this will give a low turbidity value. Turbidity measurements for the Upper Carson River watershed are reported in Figures 8 and 9. Turbidity is a water quality parameter that is particularly sensitive to short-term events such as rain storms.

The water quality objective required for the West Fork Carson River is relatively restrictive and is given in the *Lahontan Basin Plan* on page

3 - 9. It states, "The turbidity shall not be raised above a mean of monthly means value of 2 NTU." The maximum objective value for the East Fork Carson River, however, is given on page 3 - 40 and is 15 NTUs. We find that 100% (16 out of 16) of turbidity records for the West Fork Carson River, and 100% (16 out of 16) of turbidity records for the East Fork Carson River collected in 2020 fell within water quality objectives. This is an increase in the total measurements that met objectives when compared to the period of record where 78.9% (187 out of 237) of measurements in the West Fork Carson and 88.9% (233 out of 262) of measurements in the East Fork Carson met objectives.

Because turbidity is a measurement of scattered light by suspended particles, there are many factors that influence this water quality parameter. Measurements taken after a big storm where there was a lot of runoff into streams could lead to higher turbidity values. Aquatic organisms require light to survive, so changes in turbidity can have significant impacts. In places like Tahoe, water clarity is an important factor in water quality determinations, as the clarity of the lake is of a significant value to people who use the lake. In areas where pristine clarity isn't particularly a concern, turbidity may still impact the quality of the water depending on the light dependency of the organisms in those habitats, and on the composition and source of suspended particles in the water.

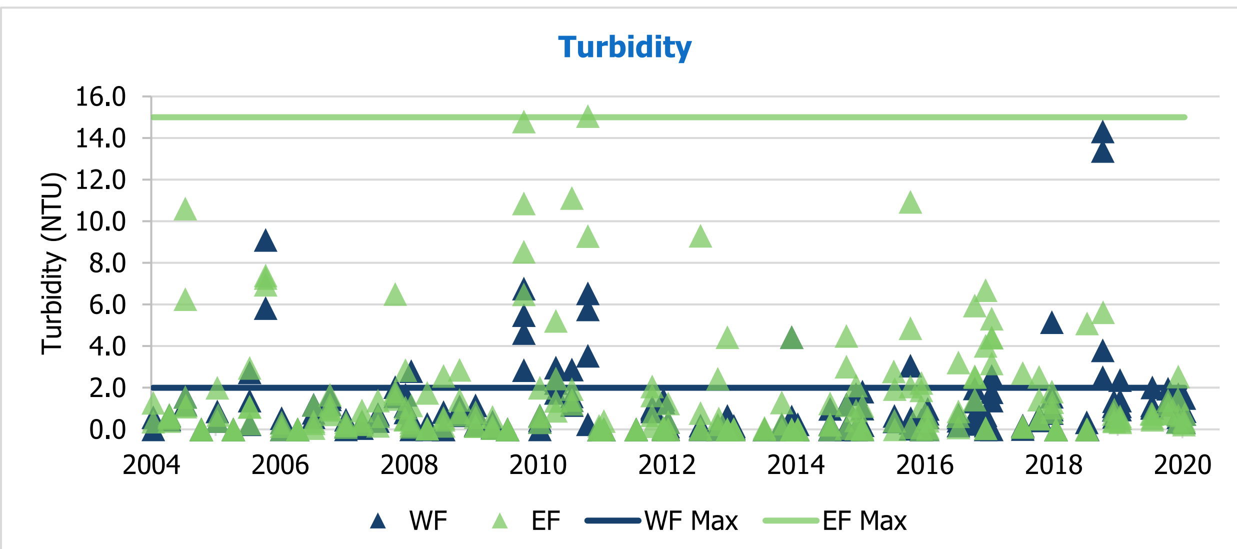

Figure 9. Turbidity measurements for the Upper Carson River watershed

Total Dissolved Solids

Calculating total dissolved solids (TDS) for our river monitoring program is a little bit complicated. Total dissolved solids are what their title describes: they are the concentration of dissolved solids or minerals in a water body. The complication is that in our program we actually measure conductivity, and then we use a conversion formula to estimate the TDS of our waters. Conductivity and TDS are related because conductivity is a measurement of how an electrical current travels through a system. In water, conductivity increases as TDS increases because the minerals help transfer electrical current better than pure water can.

The data reported in Figures 10, 11, and 12 are our conductivity measurements converted to TDS. The conversion factor we use is 0.64, which is a standard estimate that fits within the range established for fresh waters (Hem, 1985). In order to use this conversion factor, we also assume the relationship between conductivity and TDS is linear. The *Lahontan Basin Plan* sets different TDS objectives for different areas of the Upper Carson River watershed. These objectives are given in Table 3-14 on page 3 - 40, and are as follows:

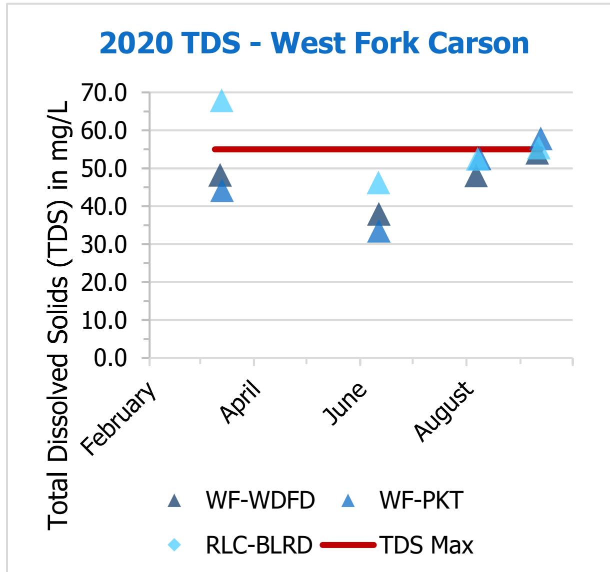

Figure 10. 2020 TDS estimates for the Upper Carson River watershed

West Fork Carson River at Woodfords:

Mean of monthly mean for the period of record:

TDS = 55 mg/L

West Fork Carson at River at Stateline:

Mean of monthly mean for the period of record:

TDS = 70 mg/L

East Fork Carson River:

Mean of monthly mean for the period of record:

TDS = 80 mg/L

Annual average value (90th percentile value):

TDS = 100 mg/L

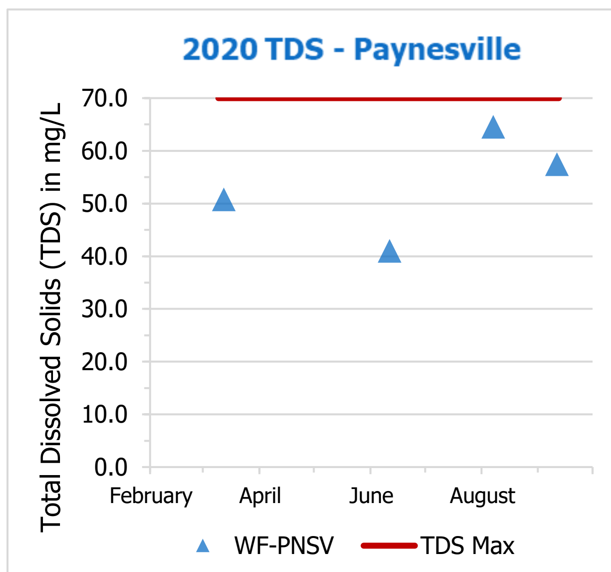

Figure 11. 2020 TDS estimates for the Upper Carson River watershed

Before 2019, we used handheld Oakton brand TDS meters in our monitoring program. While these meters are labeled TDS, they actually measure conductivity and use a conversion factor internally to estimate the TDS of the sample. In 2019, we started using more advanced YSI Pro2030 meters to measure conductivity. Because we don't have a record of the conversion factor set for the Oakton brand TDS meters, we are not reporting those results in this document. Until we are able to verify the conversion factor used prior to 2019, previous measurements and current measurements may not be comparable; therefore, only 2019 and onward data are reported here.

Using the mean of monthly mean values as the TDS objectives for this report, 75.0% (9 out of 12) of our 2020 TDS estimates for the West Fork Carson River before Woodfords met objectives; 100.0% (4 out of 4) of our 2020 TDS estimates for the West Fork Carson River at Stateline (our monitoring site at Paynesville) met objectives; and 75.0% (12 out of 16) of our 2020 TDS estimates met objectives for the East Fork Carson River. In total, 83.3% (25 out of 32) of our 2020 TDS estimates met objectives. In the graphs, please note that range values differ based on the different objective values.

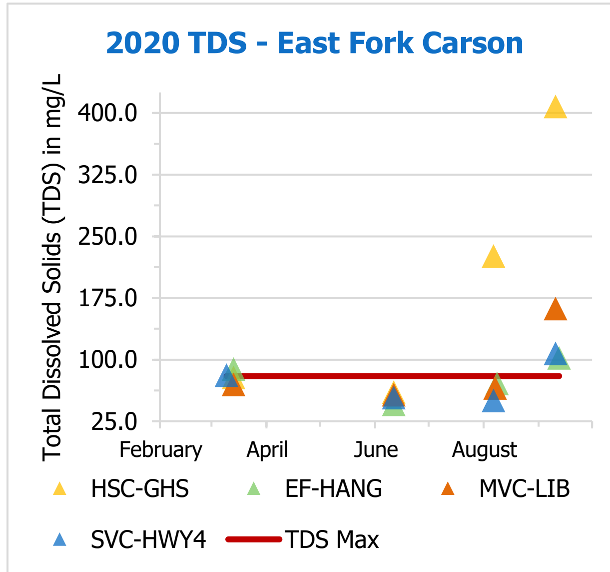

Figure 12. 2020 TDS estimates for the Upper Carson River watershed

Conclusion

Our data contribute to the overall water quality determinations for ambient waters in our region as they meet quality assurance standards set by the State Water Quality Control Board. With 17 years of data for the Upper Carson River watershed, we are able to estimate baseline values and monitor seasonal and annual variation for our monitored locations and period of record. Overall, the water quality conditions for 2020 are relatively stable. A majority of the parameters demonstrate an increase, and only the stream temperature parameter demonstrated a decrease in the percentage of measurements that meet water quality objectives compared to all years of data collection.

Limitations and Future Research

No single method for estimating normal—or natural—water quality conditions for the Upper Carson River watershed currently exists. This reports offers estimates based on real data for the purpose of this report; however, AWG will follow new developments in this process, and future reports will incorporate these changes when they occur.

While the estimated values to determine water quality objectives for this report are based on 16 years of continuous data, this data is not collected at a high enough frequency to account for a multitude of variables that affect water quality conditions. These variables range from natural variation due to things like large rain or snow events to human-caused variation due to things like reservoir releases. Additional statistical methods to determine and exclude outlier data can help validate the dataset and will result in more robust analyses. One such method is the interquartile range (IQR) method for determining outliers. Conducting this analysis to correct for outliers should include corrections based on comparable environmental conditions (such as calculating outliers per parameter for each site for each month that data is collected).

Our data do well to give us a big picture of our overall ambient water quality conditions, and for the purpose of this report, it is sufficient. Assessing the statistical significance of trends and changes over time requires collecting additional data on a more continual basis or aggregating existing data not currently in our record. Future research and reports may also consider conducting a comparative analysis with a similar watershed in the Sierra Nevada to determine if the conditions that we observe here are similar to other places with similar climatological and environmental conditions. Enhancing the quality and quantity of data collection efforts is an ongoing process, and we are grateful for the volunteers, staff, and community members that are committed to maintaining this robust monitoring program.

Acknowledgements

We would like to say thank you to all of the volunteers who donate their time and expertise, to our Restoration and Monitoring Committee members for your guidance and recommendations, to the AWG staff and board members (previous and current) who not only helped lay the foundation for this program but carried it on over the years, to all of our community members who are committed to maintaining a healthy watershed for future generations, and to the many funders who have supported AWG’s river monitoring program over the years.

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Appendix A

Stream temperature (degrees Celsius)

Date Range: 2005-2020 (August and September)

Record Count: 195

Mean: 12.03 degrees Celsius

Dissolved oxygen (mg/L)

Method 1 (10% depression of normal):

Date Range: 2005-2020 (August and September)

Count: 182

Mean: 8.19 mg/L

10% Depression of Mean = 8.19 x 0.90 = 7.37 mg/L

Method 2 (80% saturation):

Average Temperature (2005-2020): 12.0 degrees Celsius

Barometric pressure at 6000-feet elevation: 81.2 kiloPascals[1]

DO at 100% saturation: 8.61 mg/L[2]

DO at 80% saturation = 8.61 x 0.80 = 6.88 mg/L

pH

Date Range: 2005-2020 (All Months)

Record Count: 458

Mean: 7.81

Minimum pH = 7.81 – 0.5 = 7.31

Maximum pH = 7.81 + 0.5 = 8.31

Conductivity (µS/cm) to TDS (mg/L)

Conversion factor = 0.64 (estimated for irrigated agriculture beneficial use)[3]

TDS = Conductivity * 0.64[4]

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