2020 NMWRRI STUDENT WATER RESEARCH GRANT
FINAL REPORT
July 21, 2021

1. **Student Researcher:** Letisha Mailboy, New Mexico Highlands University
   Faculty Advisor: Jennifer Lindline, Ph.D., Natural Resources Management Department

2. **Project Title:** Environmental Chemistry of the Upper Pecos River; Understanding Natural and Anthropogenic Influences on Water Quality

3. **Description of Research Problem and Research Objectives.**

The Upper Pecos Watershed is one of New Mexico's montane watershed. It encompasses over 1000 km^2 of drainage of the Pecos River and its tributaries, including Cow, Bull, and Glorieta Creeks. The Upper Pecos River is the backbone of a diverse ecosystem. It provides over 150 km of high quality cold-water fishing and brings life and longevity to users within the Pecos Wilderness, Pecos Community, Santa Fe National Forest, and numerous private and public tracts.

The Upper Pecos River originates in the Sangre de Cristo Mountains at an elevation of 2,510 meters and flows almost 300 km through the Pecos Wilderness, Santa Fe National Forest, and numerous private and public tracts before entering the Fort Sumner reservoir at an elevation of 1,298 meters. The river corridor was the site of an historic lead-zinc mine in the early 1900s which has been in the reclamation phase for approximately 20 years. A 2019 proposal from a mining company to conduct exploratory drilling for gold, copper, and zinc in the mountains of Pecos is currently in review by the New Mexico Mining and Minerals Division of the New Mexico Energy, Minerals, and Natural Resources Department. It is important to understand the hydrochemistry of the Upper Pecos River so as to establish baseline water quality conditions prior to any exploration or extraction activities.

It is imperative that the quality of the water be monitored on a regular basis to ensure conditions are of safe standards for all living organisms. There are natural and anthropogenic influences that play major roles in how the quality of the water is affected.

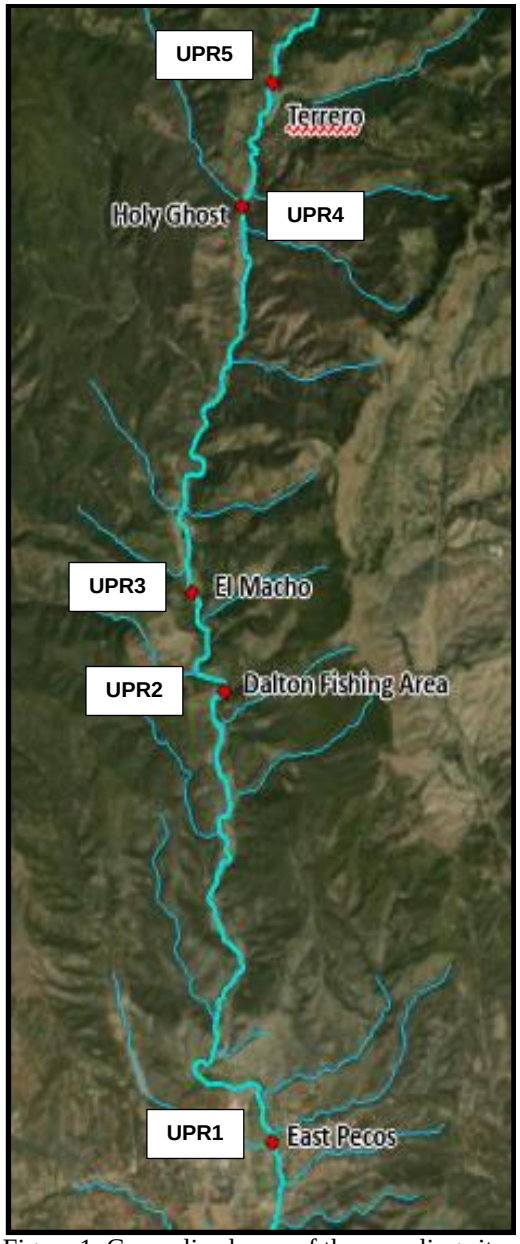

Figure 1. Generalized map of the sampling sites along the Upper Pecos River, northern New Mexico.

The natural occurrence of sulfide mineralization can lead to impairments of water quality. Similarly, anthropogenic activities such as mining, agriculture, and recreational use can also impact the water quality. The Upper Pecos Canyon area saw record number of day visitors during the COVID 19 pandemic without the support of public restrooms, raising the threat of the spread of human waste-related disease that can harm wildlife and degrade the watershed.

This research considered these circumstances and developed three hypotheses to assess the water quality the Upper Pecos River from June 2020 through May 2021.
H_o: The Upper Pecos River water quality is consistent downstream along the 25 km study reach.
H_1: The Upper Pecos River water quality degrades downstream; anions, cations, and other natural occurring elements increase downstream due to inflows from tributaries.
H_2: The Upper Pecos River water quality degrades downstream; phosphates and nitrates increase downstream due liquid waste issuances at recreation sites and/or agricultural runoff.

4. Description of Methodology Employed

To test these hypotheses, this study established 5 monitoring sites at approximately equal distances along a 25 km stretch of the Upper Pecos River. Sites were selected to capture conditions above the confluence of the historic mine site (Willow Creek) (UPR5), at the confluence of a tributary from the proposed exploratory hard rock drilling site on Jones Hill (Macho Creek) (UPR3), and at several high-use recreation areas (Terrero Village (UPR4), Dalton Canyon (UPR2), and Pecos Village (UPR1)). The project collected water samples at each of these sites on a bi-monthly basis in Winter 2021 and analyzed the samples for basic anion-cation concentrations, metals Cu, Pb, and Zn, and nutrients Phosphorous and total Nitrogen. The water chemistry data were used to characterize the hydrogeochemistry of the Upper Pecos River and assess trends, regressions, and other patterns important to the hydrochemistry throughout the study reaches. The final dataset and interpretations will be shared with the Upper Pecos Watershed Association to inform their decision making and restoration activities.

The project enlisted the services of EPA certified laboratory Hall Environmental Analysis Laboratory (HEAL) in Albuquerque, NM. Sample kits containing 3 samples per site for each sampling effort were provided by HEAL as well as labels, a cooler, chain-of-custody forms, plastic bags, and sampling instructions. A HEAL sample control manager reviewed the bottle kits prior to shipment and reviewed the submitted samples for complete chain-of-custody, temperature, volume, and other requirements.

HEAL utilized:

- EPA Method 200.8 for Metals Cu, and Pb;
- EPA Method 300.0 for Anions Fl, Cl, Nitrogen/Nitrite as N, Br, Nitrogen/Nitrate as N, Phosphorus/Orthophosphate as P, and Sulfate;
- SM2510B for Specific Conductance
- SM2320B for Alkalinity
- SM2540C MOD for Total Dissolved Solids
- EPA Method 200.7 for Metals Ca, Mg, K, Na, and Zn.

5. **Description of results; include findings, conclusions, and recommendations for further research.**

Grab samples were collected in January and March 2021 following NM Environment Department standard operating protocols for surface water sample collection. Results included:

- Phosphorous/Orthophosphate was not detectable in the sampled waters.
- Nitrogen, Nitrate (mg/L) levels ranged between 0.11-0.24 in January waters and 0.11-0.12 in March waters. Values are below the 0.25 mg/L total Nitrogen threshold. Nitrogen, Nitrate was not detected in the May and June waters.
- Sulfate (mg/L) levels increased slightly downstream with each sampling effort from 16 to 18 in January, 16 to 18 in March, 7.3 to 9.3 in May, and 10 to 11 in June.
- Chloride levels ranged from 0.74-1.30 mg/L in January samples and 0.89-1.40 mg/L in March samples. Chloride was not detected in the May and June samples.
- Metals Cu, Pb, and Zn were not detected in the sampled waters.
- Electrical conductivity (µmhos/cm) values increased downstream with each sampling event: from 200 to 250 in the January samples, from 90 to 140 in the March samples, from 110 to 140 in the May samples and 160 to 210 in the June samples.
- Total dissolved solid (mg/L) values increased downstream during the January (125 to 148), March (87 to 108), and June (89 to 114) sampling efforts. Values decreased from 68 mg/L at UPR5 to 64 mg/L at UPR1 with a high of 80 mg/L recorded at site UPR3. Note: The Upper Pecos River experienced the highest discharge in May relative to the other sampling months (Figure 3).
- Total alkalinity (mg/L Ca) values increased downstream with each sampling effort from 79.48 to 103.80 in January, 74.88 to 101.50 in March, 42.96 to 55.24 in May, and 65.80 to 95.24 in June.

All reported electrical conductivity values fell within the New Mexico Administrative Code 20.6.4.217 threshold of 300 µmhos. While no criteria are issued for total dissolved solids (TDS), sulfate, and chloride for the Upper Pecos River, criteria are established for the main stem of the Pecos River from Tecolote Creek upstream to Cañon de Manzanita for flows above 10 cfs. These thresholds include a TDS of 250 mg/L or less, sulfate 25 mg/L or less, and chloride 5 mg/L or less. The sampled Upper Pecos River waters meet the New Mexico water quality standards for TDS, sulfate and chlorate.

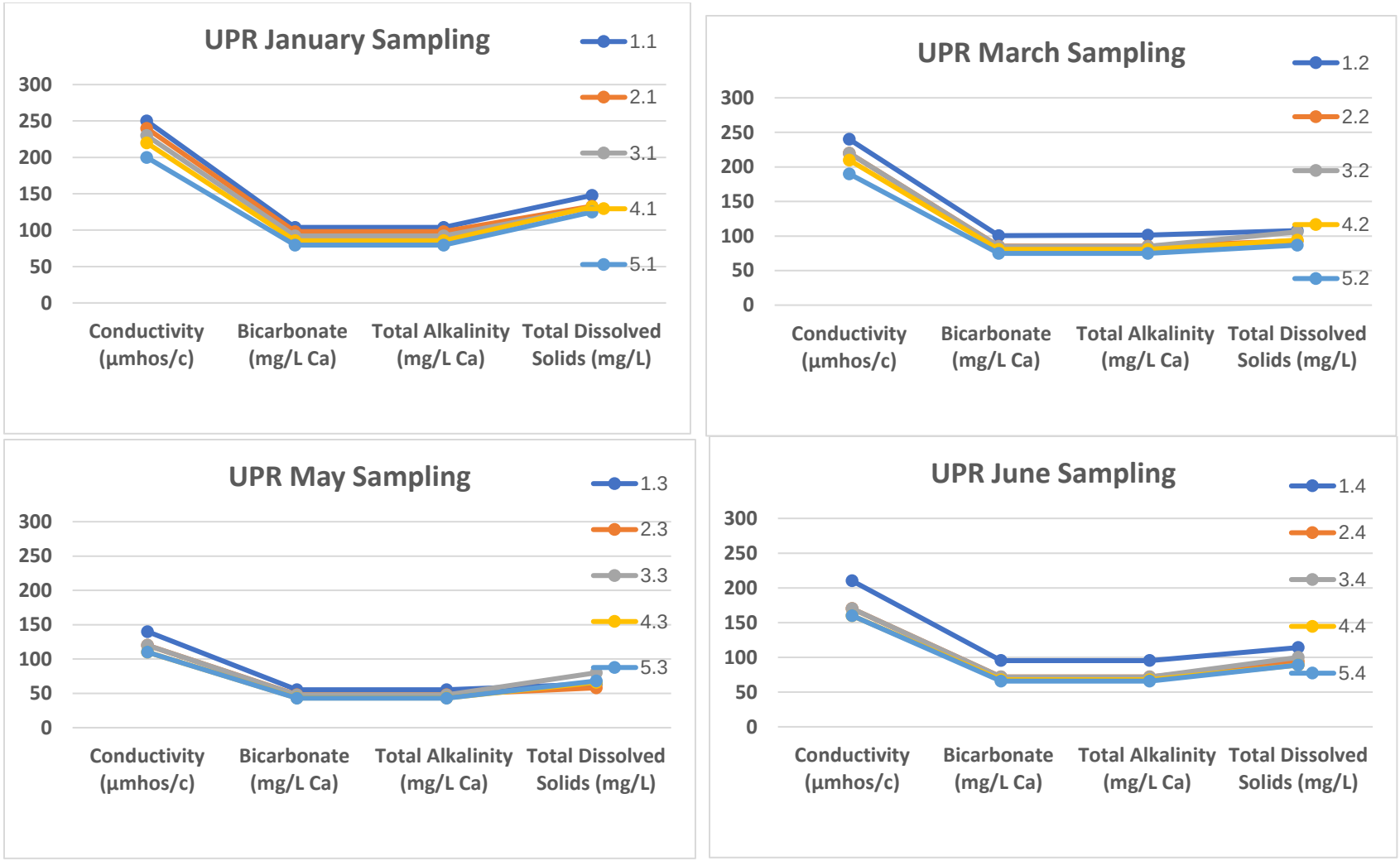

Figure 2. Composite graph showing Conductivity, Bicarbonate, Total Alkalinity, and Total Dissolved Solids values for water samples from sites UPR 1 (lowermost stretch) through UPR 5 (uppermost stretch) collected on January 18, March 17, May 13, and June 29, 2021. Note that measured values generally increased downstream throughout sampling reach. Measured values were lowest during the May sampling period which coincided with the highest discharge in the Upper Pecos River during the project period.

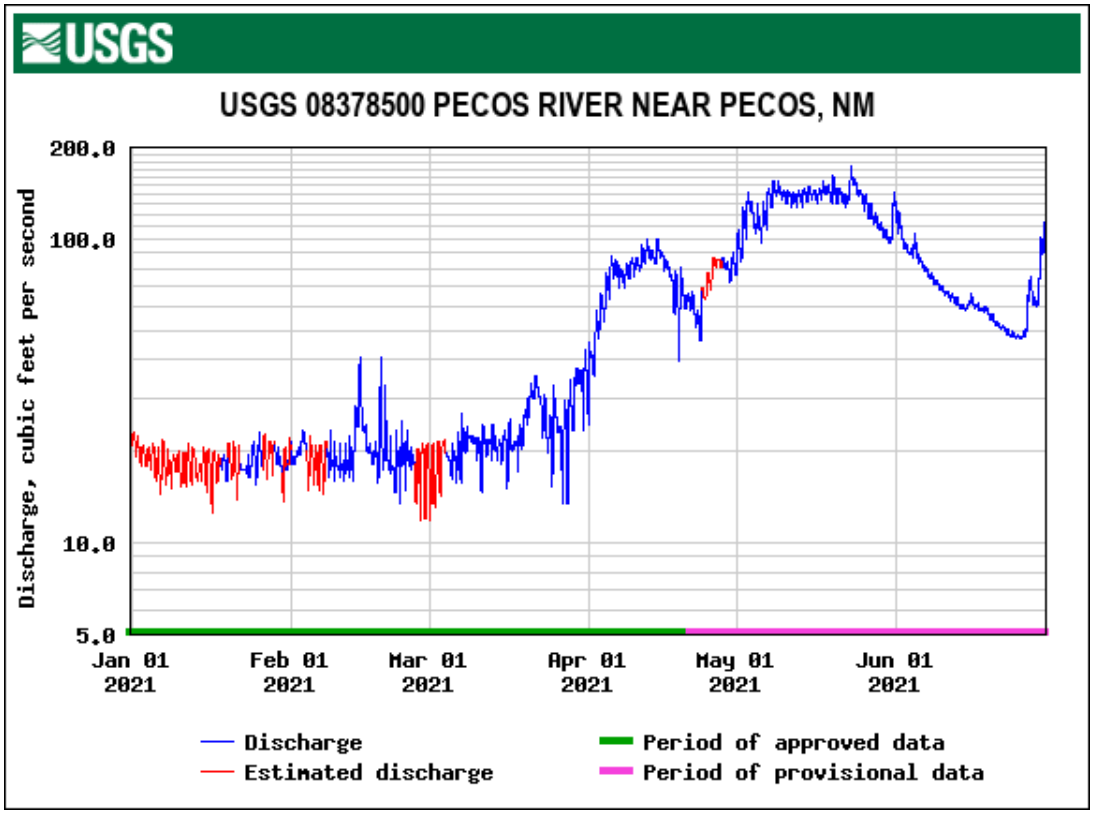

Figure 3. Discharge along the Pecos River at USGS gaging station 08378500 near Pecos, NM. For the project sampling dates, discharge averaged 17.8 ft^3/sec on January 18th, 21.3 ft^3/sec on March 17th, 138 ft^3/sec on May 13th, and 71.4 ft^3/sec on June 29th. Data from USGS Current Water Data for New Mexico (URL: https://waterdata.usgs.gov/nm/nwis/rt?).

6. Beneficiaries of Project Results.

The Upper Pecos Watershed Association is the main group to whom the results will be provided. These data will assist UPWA on their efforts to identify point and non-point source pollution and its mission to protect, restore, and maintain the health of the Upper Pecos Watershed. This study will allow for the identification of changes due increased human activity, such as mining and recreating.

The project was an important service learning experience and informative and timely water management tool for the Pecos community. The student learned field water quality monitoring techniques and worked with water quality data. She has also had the opportunity to share her results with the Upper Pecos Watershed Association, the Pecos Hydrology Workgroup, the New Mexico Geological Society, and the New Mexico Water Resources Research Institute community. The student research is more practiced and proficient in the tools and techniques of water resources science.

7. Grant Funds Spent and Budget Balance.

All of the project funds were expended towards water analysis with Hall Environmental Analysis Laboratories.

8. **Project Presentations.**
   - Presented virtually for the 2021 New Mexico Geological Society spring meeting on April 15, 2021.
   - Presented virtually with for the Upper Pecos Watershed Association Board Meeting on February 11th, 2021.
   - Presented virtually for the Pecos Hydrology Workgroup on January 28th, 2021.
   - Presented an ePoster virtually with at the NM WRRI Conference on October 29, 2020
   - An abstract of the research was published in the 17th Annual New Mexico Highlands University Faculty and Student Research and Creative Showcase Day Programs. The actual meeting was postponed until the Fall 2020 due to the COVID-19 restriction on large gatherings.

9. **Project Publications or Reports.**
   A report is in preparation for the Upper Pecos Watershed Association. The report and data will be shared with the New Mexico Environment Department's Surface Water Quality Bureau to support their assessments and fill in the gaps between their rotational monitoring.

10. **Other Student or Faculty Participants.**
    - Jennifer Lindline, Ph.D. (NMHU Faculty Sponsor)
    - Megan Begay (NMHU Undergraduate Student Project Investigator)
    - Daryl Williams (NMHU Waters Resources Laboratory Manager)
    - Kate Diem (NMHU Undergraduate Student Project Investigator)
    - Ezekiel Tapia (NMHU Undergraduate Student Project Investigator)

11. **Project Awards or Achievements.**
    New Mexico Highlands University; July 22, 2020
    Geology Students Win Grants for Pecos River Water Quality Research
    https://www.nmhu.edu/geology-students-win-grants-for-pecos-river-water-quality-research/

    The Albuquerque Journal; August 2, 2020
    NMHU students win grants for water research
    https://www.abqjournal.com/1481598/nmhu-students-win-grants-for-water-research-ex-navajo-heritage-inspired-them-to-pursue-the-project.html

12. **Student Degree Completion Plans.**
    Letisha will graduate from New Mexico Highlands University in Fall 2021with a Bachelor of Science degree in Environmental Geology with a minor in Geographical Information Systems (GIS). As an environmental geologist, she will concentrate in soil and water resources as they are important resources to all cultures and living organisms. The water quality monitoring project provided her with the opportunity to strengthen her academic skills and gain experience in field and laboratory water resources science methods.

    Letisha's career plan upon graduating is to work with the Navajo Nation Abandoned Mine Lands to aide in efforts to close, safeguard, and remediate legacy AML sites throughout New Mexico and Arizona. She hopes to volunteer her summers to cultural science camps for local communities to inspire future indigenous scientists.