GROUP A: PROJECT MANAGEMENT

A.1 Title and Approval Sheet

Quality Assurance Project Plan

Bonito Meadow Restoration Project Phase I

Submitted by:

New Mexico Environment Department
Surface Water Quality Bureau

APPROVAL SIGNATURES

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Kyla Chandler
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NELLY SMITH Digitally signed by NELLY SMITH DN: c=US, o=U.S. Government, ou=Environmental Protection Agency, cn=NELLY SMITH, 0.9.2342.19200300.100.1.1=68001003655673 Date: 2022.04.19 09:49:46 -05'00'

Nelly Smith
Chief, State and Tribal Programs Section, WDAS, EPA Region 6 — Date

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A.2 Table of Contents

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ACRONYMS

AU	Assessment Unit
BSA	Boy Scouts of America
BDA	Beaver Dam Analogs
DEM	Digital Elevation Model
DQO	Data Quality Objectives
EPA	United States Environmental Protection Agency
MAP	Mean Annual Precipitation
MAT	Mean Annual Temperature
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NWP	Nationwide Permit
QA	Quality Assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
SOP	Standard Operating Procedures
SWQB	Surface Water Quality Bureau
TMDL	Total Maximum Daily Load
WDAS	Water Division, Assistance Programs Branch, State and Tribal Programs Section

A.3 Distribution List

Table 1. below contains the distribution list, project roles and responsibilities for this project. The QA Officer will ensure that copies of this QAPP and any subsequent revisions are distributed to members who have signature authority to approve this QAPP. The SWQB Project Officer will ensure that copies of the approved QAPP and any subsequent revisions are distributed to the Project Manager. The Project Manager will distribute the QAPP to all other project personnel listed in Table 1. All members of the distribution list who do not have signature authority to approve this QAPP will review the QAPP and sign the Acknowledgment Statement prior to initiating any work for this project. The signed Acknowledgement Statements will be collected by the SWQB Project Officer and will be given to the QA Officer for filing with the original approved QAPP.

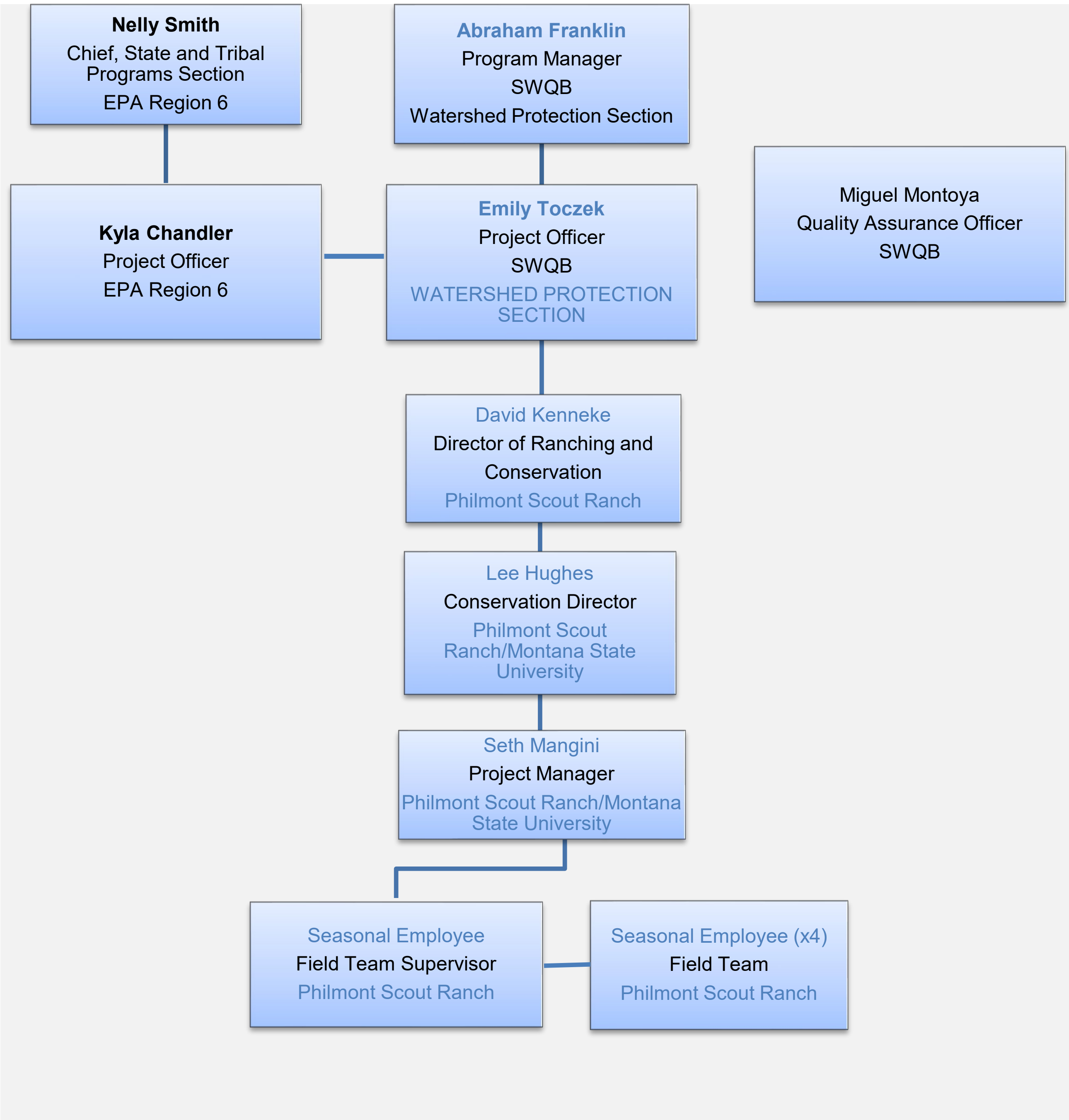
Table 1. Distribution List, Project Roles, and Responsibilities

Name	Organization	Title/Role	Responsibility	Contact Information
Abe Franklin	SWQB	Program Manager	Reviewing and approving QAPP, managing project personnel and resources	(505) 827-2793 Abraham.franklin@state.nm.us
Miguel Montoya	SWQB	QA Officer	Reviewing and approving QAPP	(505) 476-3794 Miguel.montoya@state.nm.us
Emily Toczek	SWQB	Project Officer	Preparing and revising QAPP, distribution of QAPP, project reporting, coordinating with contractors, oversight of data collection, and EPA reporting	(505) 819-8074 Emily.Toczek@state.nm.us
Dave Kenneke	Philmont Scout Ranch BSA	Director of Ranching & Conservation	Project oversight, data management, and submittal of quarterly reports	(575) 447-2366 dave.kenneke@scouting.org
Lee Hughes	Philmont Scout Ranch BSA	Director of Conservation	Project design and implementation, construction oversight	(505) 652-0989 lee.hughes@scouting.org
Seth Mangini	Montana State University/ Philmont Scout Ranch BSA	Project Manager	Field monitoring, data collection, record keeping, and submitting	(412) 496-0862 smangini05@jcu.edu
TBD	Philmont Scout Ranch	Field Team Leader	Lead restoration implementation, monitoring data collection	TBD
TBD	Philmont Scout Ranch	Field Team	Restoration Implementation	TBD
Kyla Chandler	EPA	Environmental Protection Specialist WQPD, Region 6	Reviewing and approving QAPP	(214) 665-2166 chandler.kyla@epa.com
Nelly Smith	EPA	Chief, State and Tribal Programs Section WQPD, Region 6	Reviewing and approving QAPP	(214) 665-7109 Smith.nelly@epa.gov

A.4 Project Organization

The SWQB Quality Management Plan (NMED/SWQB 2022) documents the independence of the Quality Assurance Officer (QAO) from this project. The QAO is responsible for maintaining the official approved QAPP. When changes to project objectives, methods, or monitoring are required this QAPP will be revised by the Project Manager in cooperation with the Project Officer and QAO. This QAPP will be reviewed annually by the Project Manager to determine the need for revision. Figure 1 presents the organizational structure for the Bonito Meadow Restoration Project Phase I.

Figure 1. Organization Chart



A.5 Problem Definition/Background

This QAPP refers to the Bonito Meadow Restoration Project Phase I (hereafter referred to as "Project"). The Project is being managed by the Philmont Scout Ranch BSA. The purpose of this Quality Assurance Project Plan (QAPP) is to delineate standard monitoring procedures for the project which will be used to evaluate the effectiveness of restoration activities. The loss of wetlands is a major problem in the state of New Mexico. Over 50% New Mexico's wetlands have been destroyed since the beginning of European settlement (McGraw, 2020). The incision of arroyos has been and continues to be a major contributing cause. Wetlands provide resilience in the face of drought and climate change for both human and natural communities. Bonito Creek is a headwaters-slope, wet meadow-fen complex located on Philmont Scout Ranch in the Sangre de Cristo Mountains in Colfax County, NM. Parts of the watershed are undergoing progressive channel incision resulting in the lowering of the water table and the desiccation of wetlands (Fig. 1) (Mangini and Sudmeier, 2010). This project will stabilize erosional features, rewater historic wetland areas, increase the cover of riparian vegetation, and improve water quality.

Project Area Description

The Bonito Creek Restoration Project Phase I is located in the Bonito Creek watershed (110800020302) in Colfax County, NM. Bonito Creek is a first order tributary of Rayado Creek (1108000203) and the Cimarron River (11080002). The headwaters are located at a collection of springs at 2800m (9,200') and the stream is buffered by a wet meadow-fen complex for much of its length. The watershed area is 17.5 km^2 (4,325ac). The mean annual precipitation (MAP) of the area is 650mm/yr (25.5 in.) (PRISM, 2020), falling mostly as summer monsoonal moisture and winter snowfall. Mean annual temperature (MAT) is 5.4°C (41.7°F) (PRISM, 2020). The frost-free growing season lasts from late May until September. Most watersheds in this region are characterized by deep V-shaped canyons with valley gradients of ~8-10% from their headwaters to the canyon mouths where they flow onto the plains. Bonito is morphologically different in that its valley gently descends 143m (143') over 5.5km (3.4 miles) (2.6%) and then abruptly plunges 390m (1,280') over 3.1km (1.9 miles) (12.5%) to its confluence with the Rayado River. This morphology is due to the emplacement of an erosion resistant lava flow which blocked the mouth of the canyon 4.5mya (Olmstead and McIntosh, 2004). This lava flow prevented the creek from incising as deeply as adjacent watersheds. The volcanic material is presumed to have originated from a vent on Crater Peak which lies 1.5km (0.9 miles) to the southwest of the valley (Robinson et al., 1964). The low gradient morphology of the valley is what enabled wetlands composed of fine sediment to aggrade in this watershed but not in adjacent watersheds.

Bonito Creek has an identifiable channel for most of its length, but much of the water flow is dispersed across the valley bottom or flows through underlying sediments. The wetlands of the watershed are classified as a mosaic of Rocky Mountain montane-subalpine wet meadows and Rocky Mountain montane-subalpine fens (Chimner et al., 2010; Rocchio, 2006). SWQB has conducted Hydrogeomorphic classification in this area and designates Bonito Meadow as headwater slope wetlands. These wetlands are important for the storage of carbon, water, and nutrients in an otherwise dry region (Chimner and Cooper, 2003a). Fens are peat forming wetlands in which the water table is generally within 20-30cm of the surface year-round (Malone and Lemly, 2021; Rocchio, 2006; USFWS, 1999). Wet meadows are differentiated by a seasonally variable water table and lack of peat accumulation (Malone and Lemly, 2021; Reid, 2020). Peat accumulation in such systems is slow (20-28 cm/ka in similar systems in Colorado) (Cooper, 1990; USFWS, 1999) and so these systems are very slow to regenerate following disturbance. Even brief drops in the water table, such as occurs during the formation of an arroyo, enable oxygen to oxidize peat horizons to CO_2 (Chimner and Cooper, 2003c; Cooper, 1990).

The watershed hosts plant communities typical of the southern and central Rocky Mountain region. Forests consist of montane to subalpine mixed conifer communities. South facing and lower elevation areas have stands of Ponderosa pine (*Pinus ponderosa*), white fir (*Abies concolor*), and Douglas fir (*Pseudotsuga menziesii*). North facing and higher elevations host Engelmann spruce (*Picea engelmannii*)-subalpine fir (Abies lasiocarpa) communities. Other common tree species include aspen (*Populus tremuloides*), limber pine (*Pinus flexilis*), and Colorado blue spruce (*Picea pungens*). Perennially wet areas are dominated by sedge (*Carex* ssp.) and tufted hairgrass (*Deschampsia cespitosa*). More mesic sites host native bunchgrasses such as Idaho fescue (*Festuca idahoensis*), Arizona fescue (*Festuca arizonica*) and introduced species such as timothy (*Phleum pretense*), Kentucky bluegrass (*Poa pratensis*), and orchardgrass (*Dactylis glomerata*). Clover (*Trifolium* ssp.) is abundant and it is possible that the meadow was at one time seeded with introduced species. An area which has been fenced and partially excluded from grazing contains a significant stand of Bebb willow (*Salix bebbiana*), mountain alder (*Alnus incana*) and currants (*Ribes* ssp.). These species are no longer present in the rest of the watershed, but snags throughout the valley testify to their previous presence.

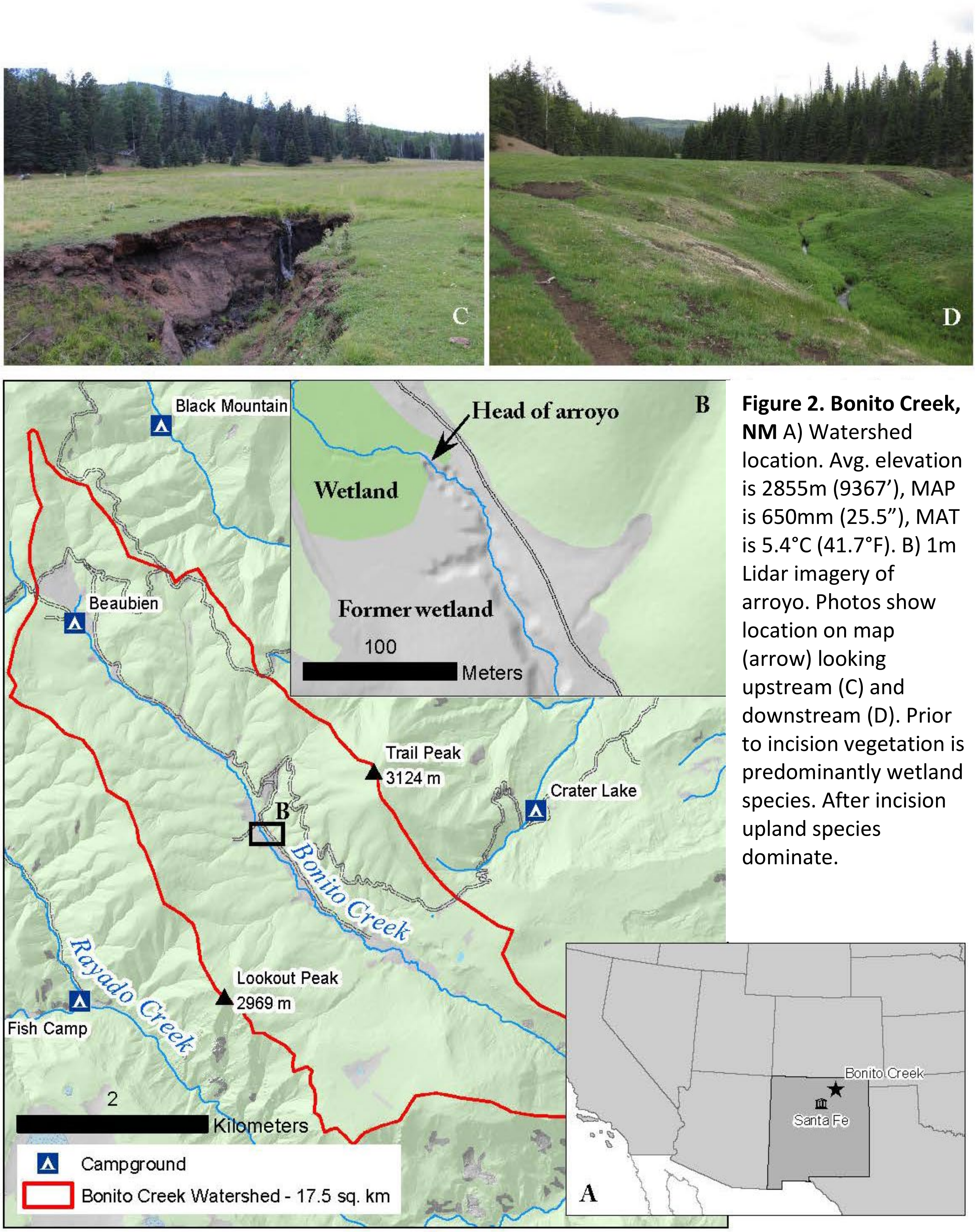


Figure 2. Bonito Creek, NM A) Watershed location. Avg. elevation is 2855m (9367'), MAP is 650mm (25.5"), MAT is 5.4°C (41.7°F). B) 1m Lidar imagery of arroyo. Photos show location on map (arrow) looking upstream (C) and downstream (D). Prior to incision vegetation is predominantly wetland species. After incision upland species dominate.

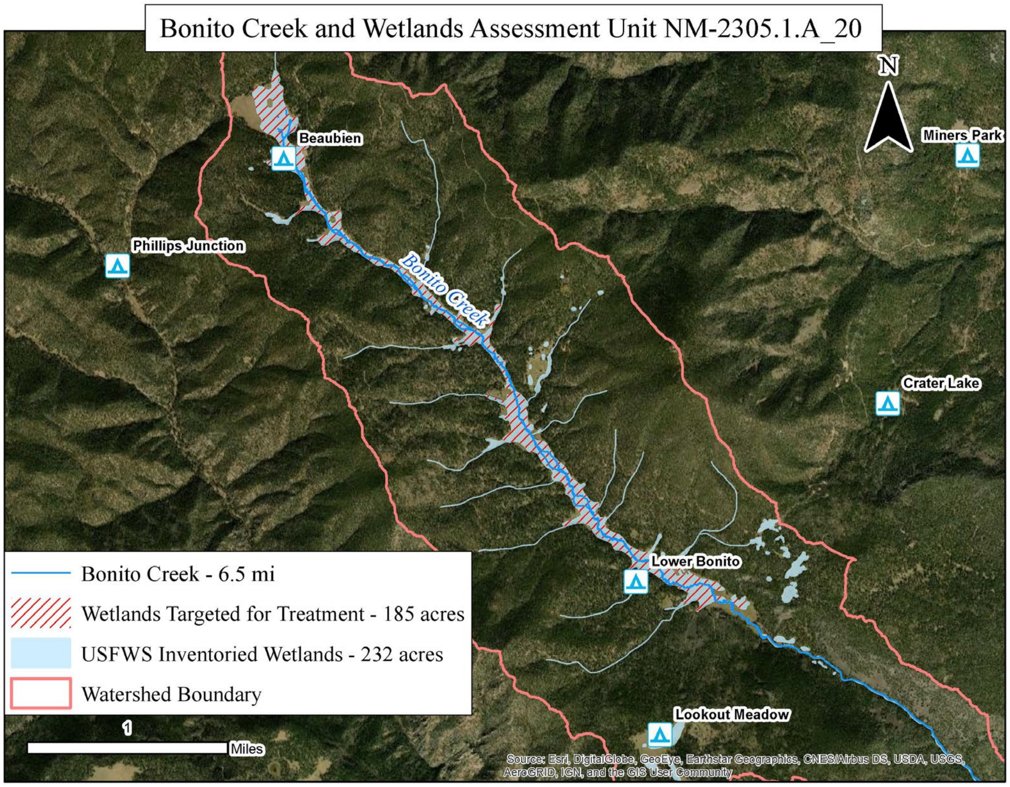


Figure 3. Bonito Wetlands

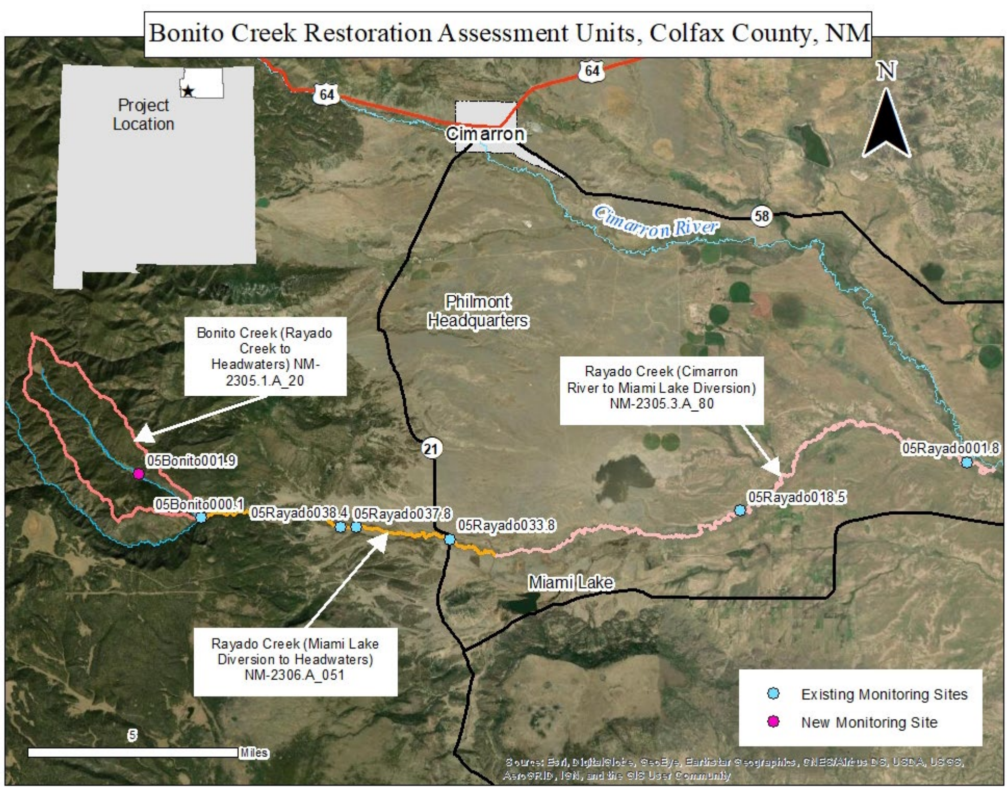


Figure 4. Greater Project Area Map

Table 2. Waterbody Assessment Units for the Project

Assessment Unit IS	AU Name	12-Digit HUC or Latitude and Longitude	WQS citation/reference
NM-2305.1.A_20	Bonito Creek (Rayado Creek to Headwaters)	110800020302	20.6.4.309
NA	Bonito Meadow (wetlands adjacent to creek)	36 24'31.36" N 105 5'1.19" W	General Criteria 20.6.4.13
NM-2306.A_051	Rayado Creek (Miami Lake Diversion to headwaters))	110800020306	20.6.4.309
NM-2305.3.A_80	Rayado Creek (Cimarron River to Miami Lake Diversion)	110800020306	20.6.4.307

Background

Bonito Creek is an important contributor water to the Rayado, Cimarron, and Canadian River watersheds. Because it is a headwaters stream with significant groundwater storage it provides buffering of downstream flow during times of drought. Current data shows that the wetlands of Bonito Creek have been accumulating for at least the past ~2000 years (Mangini, 2020 unpublished), and perhaps longer. Sedimentary evidence shows that fire has been an important driver of wetland formation. Valley sediments show repetitive cycles of fire, post-fire debris flows, and organic rich wetland sediments (Fig. 5a) (Mangini, 2020 unpublished). Alluvial fans have played a prominent role in the formation of wetlands in this valley. Following large fires, sediment from side drainages is deposited on alluvial fans. This obstructs the main valley and the flow of Bonito Creek leading to the formation of wetlands upstream from these alluvial fans (Fig. 5b).

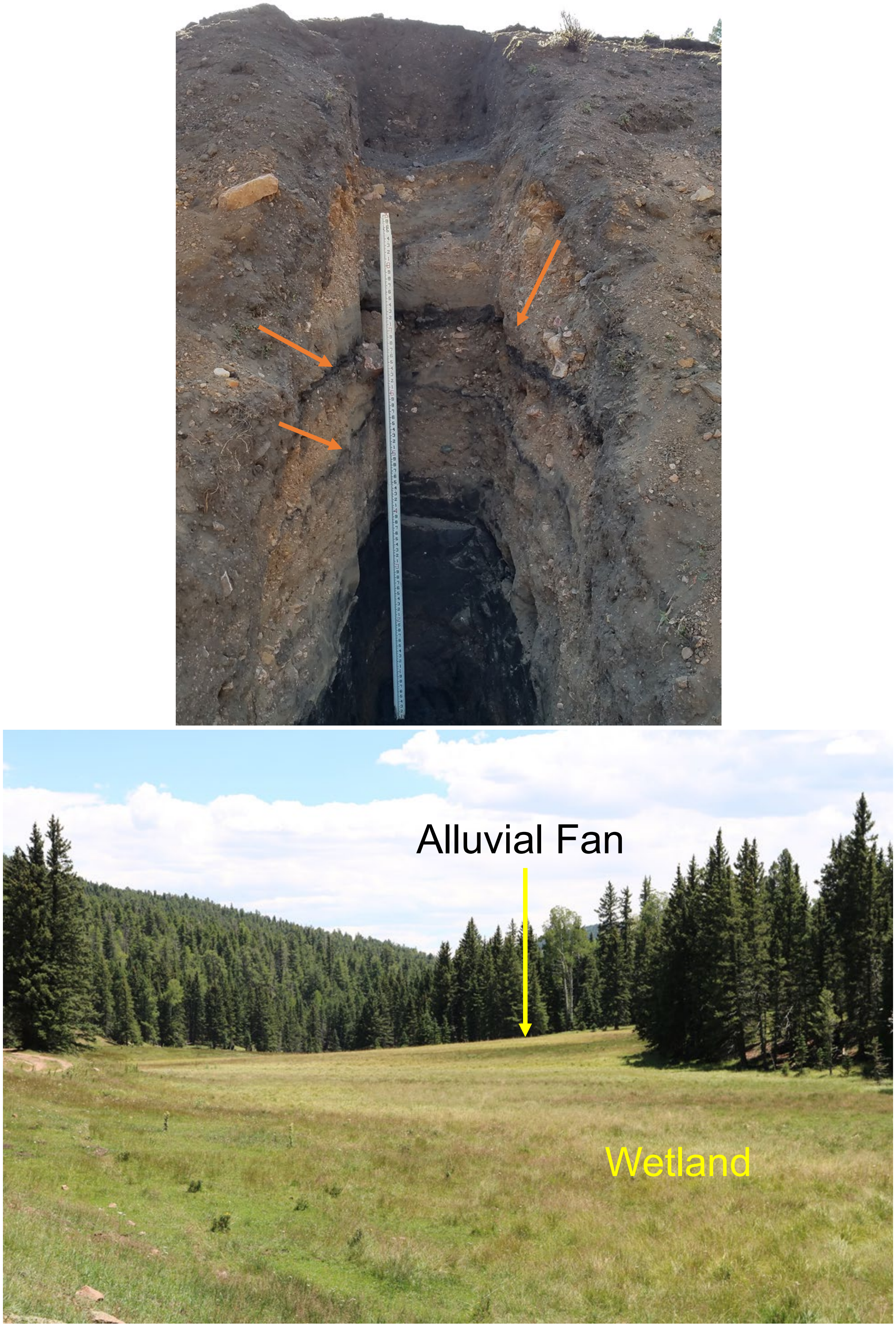


Figure 5. a.) layers of charred organic soil with overlying layers of coarse sediment. Indicates cycles of wetland formation, fire, and debris flows. B.) Alluvial fan and upstream wetland along Bonito Creek

The valley bottom today is an open meadow but was historically likely a mosaic of woody (willows and alders) and herbaceous wetlands. In the past century and a half (+/-) the valley bottom has had much of its woody vegetation removed which has likely been a major driver of the formation of gullies propagated by large headcuts. The wetlands and riparian zones have been altered/damaged by overgrazing, trampling, and poorly placed infrastructure. Aerial photography shows that these processes were well underway by the 1950's (Fig. 5).

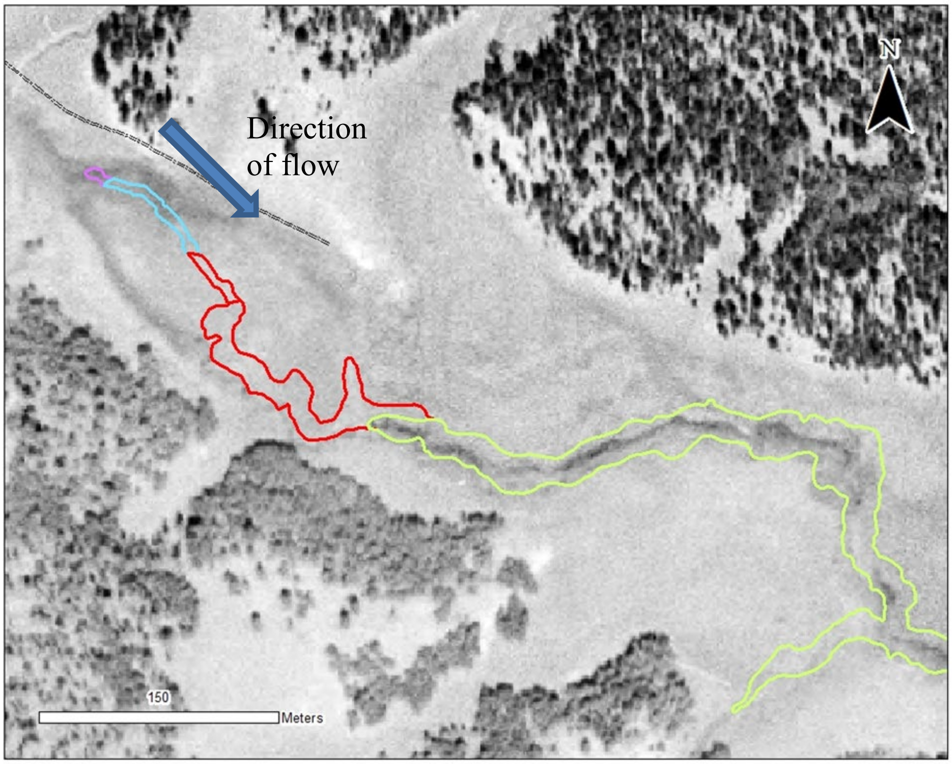


Figure 6. Aerial photograph from 1954 showing extent of a major arroyo in Bonito Creek. Red (1984), blue (2009), and purple (2018) show growth over time. Note lack of woody riparian species even during this time. On the ground snags of willows are visible, showing that they were once more abundant.

Bonito Creek is included in the 2020-2022 State of New Mexico Clean Water Act Section 303(d)/Section 305(b) Integrated report (NMED, 2020-2022). An initial assessment of Bonito Creek is described on p. 20 of the Cimarron River Watershed Based Plan (WBP) (Hilton, 2012). Bonito Creek has not been previously assessed for water quality but will be during this project. However, it likely contributes to sediment, temperature, nutrient, and E. coli impairments in two reaches of the Rayado River downstream (Fig. 4). Of the two reaches of the Rayado below the confluence with Bonito Creek the first (NM-2306.A_51, Rayado Creek (Miami Lake Diversion to Bonito Creek confluence)) is listed as impaired for temperature and E. coli with TMDLs for both. The second, (NM-2305.3.A_80, Rayado Creek (Cimarron River to Miami Lake Diversion)) is listed as impaired for nutrients, sediment, and E. coli with TMDLs for sediment and nutrients. The Spreadsheet Tool for Estimating Pollutant Loads (STEPL) modelling estimates 2,918 lbs. of nitrogen and 1,019 lbs. of phosphorous are discharged into Bonito Creek each year. STEPL modelling of gully erosion estimates that as much as 1,235 tons of sediment per year may be discharged due to gully enlargement. The Watershed Erosion Prediction Project (WEPP) estimates road infrastructure discharges 7 tons per year.

Objective
This project will attempt to reverse channel incision, wetland degradation, riparian vegetation loss and the water quality impairments associated with these. Data collection will be conducted to determine the effectiveness of restoration treatments by evaluating changes to stream morphology, riparian vegetation cover, water temperature, water quality indicators (dissolved oxygen, turbidity, nutrient loading, coliform, and E. coli), stream flow, surface water and groundwater storage.

A.6 Project/Task Description

Description
The Project will accomplish its objectives utilizing a suite of structures to arrest headcut propagation, rewater historic wetlands, and recover riparian and wetland vegetative communities. The study/project consists of individual restoration tasks coupled to monitoring methods to determine whether restoration goals are being met. This will be elaborated in more detail in Data Generation and Acquisition section B1.

Restoration Activities
A full description of restoration activities planned for Bonito Creek is available at:
https://sethmangini.files.wordpress.com/2021/04/bonito-creek-restoration-plan-draft-ii-whole.pdf

Restoration activities will include structures to control headcuts (stone Zuni bowls and log and fabric step fall structures), one rock dams, beaver dam analogs, water spreading structures which deliver water back onto historic wetland areas, and exclosure fencing to allow the recovery of woody riparian/wetland vegetation from browsing by domestic and wild ungulates. Activities began in the summer/fall of 2021 and will continue through May 2024.

Task 1 – Stop upstream progression of headcuts and enlargement of gullies
Assessment Unit(s): NM-2305.A_20Bonito Creek (Rayado Creek to Headwaters), Bonito Meadow Wetlands
Methods: installation of Zuni bowls, log and fabric stepfall structures
Monitoring: photo points, longitudinal profiles

Task 2 – Re-aggrade stream bed in incised reaches
Assessment Unit(s): NM-2305.A_20 Bonito Creek (Rayado Creek to Headwaters)
Methods: one rock dams, beaver dam analogs, “mini-beaves” (see restoration plan for description)
Monitoring: cross sections

Task 3 – Increase stream base flow
Assessment Unit(s): NM-2305.A_20 Bonito Creek (Rayado Creek to Headwaters)
Methods: Beaver dam analogs, restoration of sheet flow over historic wetland areas

Monitoring: Stream flow gauge (installed 2020) and weather station (installed 2020)

Task 4 – Reduce Sediment Loads
Assessment Unit(s): NM-2305.A_20 Bonito Creek (Rayado Creek to Headwaters), NM-2305.3.A_80 Rayado Creek (Cimarron River to Miami Lake Diversion)
Methods: Installation of erosion control structures on headcuts, retiring/replacement of poorly placed roads/trails, beaver dam analogs to capture fine sediment, restored wetlands to capture fine sediment
Monitoring: In-Situ probe with turbidity sensor, STEPL modelling, WEPP modelling

Task 5 – Assess and Reduce Nutrient Loads (nitrogen and phosphorous)
Assessment Unit(s): NM-2305.A_20 9 Bonito Creek (Rayado Creek to Headwaters),
Methods: Construction of fencing to keep ungulates out of riparian zone, restoration of wetlands with water spreading devices which allow wetlands to remove nutrients prior to downstream discharge
Monitoring: water samples sent to accredited water quality lab, use of in field-monitoring kits for nitrogen and phosphorous, sonde measurements

Task 6 – Assess and Reduce E. coli Loads
Assessment Unit(s): NM-2305.A_20 Bonito Creek (Rayado Creek to Headwaters), NM-2306.A_051 Rayado Creek (Miami Lake Diversion to Bonito Creek confluence), NM-2305.3.A_80 Rayado Creek (Cimarron River to Miami Lake Diversion)
Methods: Construction of fencing to keep ungulates out of riparian zone, restoration of wetlands with water spreading devices which allow wetlands to remove nutrients prior to downstream discharge
Monitoring: E. coli levels will be monitored by field sampling and laboratory analysis.

Task 7 – Assess and Reduce Peak Stream Temperatures
Assessment Unit(s): NM-2305.A_20 Bonito Creek (Rayado Creek to Headwaters), NM-2306.A_051 Rayado Creek (Miami Lake Diversion to Bonito Creek confluence)
Methods: Increase shade by recovering streamside vegetation with exclosures around riparian zone, restoration of wetland areas and installation of beaver dam analogs to recharge groundwater
Monitoring: One temperature measurement station was installed in 2020 (Onset HOBO sensor), additional temperature sensors will be installed (Onset HOBO sensors and In-Situ sonde sensors)

Task 8 – Increase area covered by wetland/riparian vegetation
Photo points, remote sensing
Assessment Unit(s): NM-2305.A_20 Bonito Creek (Rayado Creek to Headwaters), Bonito Meadow Wetlands
Methods: Construct exclosures around riparian zone, restore wetland areas
Monitoring: Ground based photopoints, aerial remote sensing/photography (validated with ground-based transects)

Task 9- Increase groundwater in historic wetland areas

Assessment Unit(s): Bonito Meadow Wetlands
Methods: Install water spreading devices to rewater historic wetlands
Monitoring: Monitoring wells, electric resistivity (ER) transects

Task 10 – Measure surface water storage from beaver dam analogs
Assessment Unit(s): NM-2305.A_20 Bonito Creek (Rayado Creek to Headwaters)
Methods: Increase surface water storage using beaver dam analogs
Monitoring: Use of drone flights to create digital elevation models before and after BDA installation to measure volume of water stored behind dams

Other Water Quality Monitoring Metrics – Other water quality monitoring metrics will also be measured to provide information about baseline stream conditions and effects of the restoration project. These metrics will include dissolved oxygen (DO), pH/ORP, and conductivity. A sonde containing these instruments will be installed at monitoring station 1 (Fig. 4). A second sonde will be used to check the calibration of the in-situ sonde and for spot measurements at other monitoring locations in the watershed.

Schedule
The project schedule is summarized in Table 3. Initial evaluation of Bonito Creek was conducted from 2010 – 2015 and the concept of a restoration project was conceived during this time. Restoration design planning was completed in 2020 as part of the PhD project of Seth Mangini. 404/401 Permits were obtained in the spring of 2021. Restoration construction began during the summer of 2021. The monitoring activities described in Project/Task Description will commence upon approval of the QAPP, with the exception of certain activities which were begun prior to application to the 319 program. These are designated with an asterisk*.

Table 3. Project tasks, products, responsible party, timeline (Use as applicable)

Task	Product	Responsible Party	Approx. State Date	Approx. Completion Date
Develop restoration plan	Restoration Design	Seth Mangini	Aug. 2020	Dec. 2020
Permitting	404/401 Permits with ACE and NMED	Seth Mangini	March 2021	June 2021
Administrative	Procurement of supplies for contract	Seth Mangini, David Kenneke, Lee Hughes	July 2021	Nov. 2023
Quality Assurance Project Plan	Approved QAPP	Seth Mangini	Nov. 2021	April 2022

Stream Flow/Temperature Measurement	Gauging with staff and pressure transducer	Seth Mangini, Lee Hughes, Seasonal Stream Restoration Team	Sept. 2020*	June 2024*
Weather Measurement (temperature and precipitation)	HOBOware datalogging temperature and precipitation station	Seth Mangini, Lee Hughes, Seasonal Stream Restoration Team	Sept. 2020	June 2024*
Pre-treatment Electric Resistance Groundwater Transects	Groundwater Mapping	Seth Mangini, Seasonal Stream Restoration Team	Aug. 2019* Aug. 2021*	June 2022*
Pre-treatment Groundwater Monitoring Well Installation	Depth to groundwater measurement	Seth Mangini, Seasonal Stream Restoration Team	Aug. 2021*	June 2022
Water Quality Nutrient Monitoring	Laboratory and field analysis	Seth Mangini, Lee Hughes, Seasonal Stream Restoration Team	May 2022	June 2024
Water temperature monitoring	Installation of additional In-stream temperature probes	Seth Mangini, Lee Hughes, Seasonal Stream Restoration Team	May 2022	June 2024
Water Quality E. coli monitoring	Laboratory analysis	Seth Mangini, Lee Hughes, Seasonal Stream Restoration Team	May 2022	June 2024
Pre-treatment/restoration Sonde Data Collection	Stream temperature, turbidity, pH, DO, and specific conductivity	Seth Mangini, Lee Hughes, Seasonal Stream Restoration Team	May 2022	Nov. 2022

Pre-treatment/restoration fluvial geomorphology assessment	Cross sections, longitudinal profile, pebble counts, slope and flow	Seth Mangini, Seasonal Stream Restoration Team	May 2022	June 2022
Pre-Beaver Dam Analog Topography	Drone created digital elevation models	Seth Mangini, Lee Hughes, Seasonal Stream Restoration Team	May 2022	August 2022
Pre-treatment/restoration vegetation monitoring	Wetland vegetation cover, woody riparian canopy cover, NDVI Index	Seth Mangini, Lee Hughes, Seasonal Stream Restoration Team	June 2022	Nov. 2022
Pre-treatment photography	Photo points	Seth Mangini, Seasonal Stream Restoration Team	June 2022	July 2022
Implementation of restoration design	Restoration implementation	Seth Mangini, Lee Hughes, Seasonal Stream Restoration Team	July 2021	Sept. 2023
Post-treatment Electric Resistance Groundwater Transects	Groundwater Mapping	Seth Mangini, Seasonal Stream Restoration Team	June 2023	May 2024
Post-treatment Groundwater Monitoring Well Monitoring	Depth to groundwater measurement	Seth Mangini, Seasonal Stream Restoration Team	June 2023	May 2024
Post-treatment/restoration Sonde Data Collection	Stream temperature, turbidity, pH, DO and specific conductivity	Seth Mangini, Lee Hughes, Seasonal Stream Restoration Team	May 2023	June 2024
Post-treatment fluvial geomorphology assessment	Cross sections, longitudinal profile, pebble count, slope and flow	Seth Mangini, Lee Hughes, Seasonal Stream Restoration Team	Sept. 2023	June 2024

Post-Beaver Dam Analog Topography	Drone created digital elevation models	Seth Mangini, Lee Hughes, Seasonal Stream Restoration Team	Sept. 2022	June 2024
Post-treatment vegetation monitoring	Wetland vegetation cover, woody riparian canopy cover, NDVI Index	Seth Mangini, Lee Hughes, Seasonal Stream Restoration Team	Sept. 2023	June 2024
Post-treatment photography	Photo points	Seth Mangini, Seasonal Stream Restoration Team	May 2024	June 2024
Reporting to SWQB Project Officer	Quarterly	Philmont Scout Ranch	Sept. 2021	June 2024
Reporting to EPA	Quarterly and Final Report to EPA	Emily Toczek	July 2021	June 2024

Monitoring Location Selection Criteria

Water Quality

One water quality monitoring site has already been selected in the Bonito Creek AU (Table 4) (Fig.4). This location was chosen because it was the most downstream location in Bonito Creek which is still in the wet meadow portion of the watershed. Below this point the creek becomes a cascade which drops ~1000' to the confluence with the Rayado River. A stream gauge (pressure/temperature transducer) has been in place at this location since September 2020 (prior to application to EPA 319 grant). A sonde will be deployed at this location in 2022. Additional Monitoring sites will be selected at the beginning of monitoring (spring 2022) by the Project Manager using best professional judgment so that the data can meet project objectives. These locations will have in-situ temperature sensors and/or will be subject to periodic measurements of instantaneous (grab) water quality sampling. Instantaneous water quality measurements will be collected by dipping the sonde into stream when possible and collecting samples for chemical analysis. The additional monitoring sites will be selected in consultation with NMED for a representative sampling of sub-environments along Bonito Creek and adjacent wetlands.

Water quality monitoring stations in Rayado Creek AUs (Table 2) were last monitored in 2018 and are scheduled to be monitored again in 2023-2024 by NMED/SWQB personnel.

Physical (Geomorphic) Assessment/measurements

Cross section locations were determined during the 404/401 permitting process (see Nationwide Permit 27 (NWP27)) and by the locations of existing cross sections which were installed during initial assessment in 2010 – 2015. A longitudinal profile with permanent monuments every 100' of channel length were installed in 2010. Longitudinal profiles will be conducted as part of monitoring to ensure headcuts are stabilized.

Photopoint Locations

Photopoint locations were determined during 404/401 (see NWP 27) permitting process and by the locations of existing photopoints installed during initial assessment in 2010 – 2015.

Groundwater Monitoring Wells and Electric Resistivity Mapping

To determine the success of "mini-beave" water spreading structures (see Restoration Plan) two areas of degraded wetland were selected for monitoring with wells and Electric Resistance (ER) tomography. These reaches will have valley cross sections with sets of 4-5 wells spaced along each. ER tomography of each cross section will be conducted pre- and post-treatment. ER mapping uses a set of 24 electrodes set along the cross section to make a map of the water table using electrical resistance (see methods Fig. 7). Since saturated sediments are more conductive than unsaturated sediments, they are more conductive. Combining ER cross sections with well data will aid interpretation. The first ER cross sections were conducted in 2019 as part of Seth Mangini's PhD field work. A second set was done during August 2021. Several monitoring wells were set along transects during August 2021. This was necessary because the ER instrument was available at that time (on loan from Montana State University). Additional, well installation will be completed during the summer of 2022.

Drone Mapping of BDA Response

If practical, a drone will be used to make high resolution Digital Elevation Models of reaches where BDA's will be installed before and after BDA installation. If successful, the volumetric difference between pre- and post- BDA installation DEM's will allow accurate measurement of surface water storage. The locations of BDA installations are available in the restoration plan and 404 permit.

Table 4. Water Quality Monitoring Sites

Monitoring Station ID	WQS Citation	Assessment Unit ID	12-Digit HUC or Latitude and Longitude
05Bonito000.1*	20.6.4.309	NM-2305.1.A_20 Bonito Creek (Rayado Creek to Headwaters)	110800020302
05Bonito001.9	20.6.4.309	NM-2305.1.A_20 Bonito Creek (Rayado Creek to Headwaters)	110800020302
05BonitoTBD	20.6.4.309	NM-2305.1.A_20 Bonito Creek (Rayado Creek to Headwaters)	110800020302
05BonitoTBD	20.6.4.309	Bonito Meadow (wetlands adjacent to creek)	36 24'31.36" N 105 5'1.19" W

05Rayado041.0*	20.6.4.309	NM-2306.A_051 Rayado Creek (Miami Lake Diversion to Bonito Creek confluence)	110800020306
05Rayado038.4*	20.6.4.309	NM-2306.A_051 Rayado Creek (Miami Lake Diversion to Bonito Creek confluence)	110800020306
05Rayado37.8*	20.6.4.309	NM-2306.A_051 Rayado Creek (Miami Lake Diversion to Bonito Creek confluence)	110800020306
05Rayado033.8*	20.6.4.309	NM-2306.A_051 Rayado Creek (Miami Lake Diversion to Bonito Creek confluence)	110800020306
05Rayado018.5*	20.6.4.307	NM-2305.3.A_80 Rayado Creek (Cimarron River to Miami Lake Diversion)	110800020306
05Rayado001.8*	20.6.4.307	NM-2305.3.A_80 Rayado Creek (Cimarron River to Miami Lake Diversion)	110800020306

*SWQB established monitoring station

A.7 Quality Objectives and Criteria for Measurement Data

The baseline data collection and monitoring components of the Project are intended to answer the following questions:

1) Are restoration treatments laid out in the Bonito Creek Restoration Plan and project Sub-Grant Agreement effective?

2) Can changes be measured in stream morphology, water quality, wetland area, vegetation type and density, surface and groundwater abundance and distribution in the project Assessment Units (AUs).

Stated as a decision: 1) The information gathered as part of the baseline data collection and monitoring will be used to determine the effectiveness of restoration treatments and 2) determine future restoration actions.

Data Quality Objective (DQO)

The quality of the data will be adequate to provide a high level of confidence in determining whether project objectives have been met. Data gathered during this project must consider Data Quality Indicators (DQIs) identified in Table 5 and must be of sufficient quality to provide a high level of confidence in the resulting decisions.

Data Quality Indicators

The measurement quality objectives will be sufficient to achieve the DQO and will be in conformance with those listed in the SWQB's QAPP. The Data Quality Indicators listed in the SWQB's QAPP and applicable to the data collected for this project are precision, bias, accuracy, representativeness, comparability, completeness, and sensitivity.

Table 5. Data Quality Indicators

DQI	Determination Methodologies
Precision	The degree of variation in repeated measurements of the same quantity are measured and quantified so that the range of uncertainty using a given method is known. Uncertainty is minimized by assuring samples are taken in a consistent and repeatable manner as described in the procedures and SOPs identified in this QAPP.
Bias	The sampling conducted under this QAPP will mostly compare a set of sampling sites over time. Systematic bias could result from sampling processes which cause error in one direction. Bias will be minimized by training staff in proper sampling procedures according to SOPs and monitoring methods approved in this QAPP.
Accuracy	The degree to which a measurement reflects the true value of the parameter being assessed is enhanced through routine calibration practices as described in applicable SOPs and the use of equipment with a range of accuracy within the decision criteria. Acceptable levels of accuracy are specified in SOPs and are verified through evaluation of duplicate, spiked, and field blank sampling as appropriate.
Representative	Sampling locations and methods are designed to measure accurately and precisely spatial and temporal variations of parameters through the whole sampling area.
Comparability	Data collected must be comparable, i.e., utilize standard methods which allow for comparison of changing parameters temporally and between studies. The spatial accuracy of repeated measurements at sampling locations will be aided by the installation of durable survey monuments and recording of these locations using high-resolution GPS measurements.
Completeness	To ensure confidence in datasets for use in project decisions all surveys and other methodologies will be completed in their entirety as identified in this QAPP, the Bonito Creek Restoration Plan, and in monitoring plan delineated in 404/401 permitting.
Sensitivity	Sensitivity is the ability of an analytical method or instrument to detect the parameter of interest above background noise and above the inherent uncertainty of the analytical method. Appropriate sensitivity allows null measurements to be differentiated from low levels of a measurement parameter. Methods/instruments with appropriate levels of sensitivity will be selected for given parameters in accordance with Best Practices, SOPs, and this QAPP.

A.8 Special Training/Certification

This project, including data collection and monitoring, will be primarily implemented by Seth Mangini (Project Manager). Mangini is a PhD student at Montana State University specializing in geology, geomorphology, and restoration who is completing this project as part of his graduate work. He is employed by Philmont Scout Ranch in Cimarron, NM, the landowner of the project area. Mangini and other Philmont Personnel (as indicted in Distribution List) will train seasonal crews tasked with the implementation of the restoration project. Mangini and other Philmont Personnel will be familiar with procedures identified in SOPs referenced in this QAPP. Distribution of the QAPP, technical assistance, and oversight of data collection will be provided by the SWQB Project Officer.

Volunteers will be trained by Mangini, the seasonal stream restoration team, and other designated Philmont employees and always supervised by these parties. Seasonal personnel may assist with data collection, as may certain volunteers, who will be closely supervised by one of these trained parties. Any individual conducting work for the project (with the exception of volunteers) will review this QAPP and sign the acknowledgment statement prior to initiating any work for this project. The signed acknowledgment statements will be kept on file with the final EPA approved QAPP and will be given to the QA Officer for filing by the SWQB Project Officer.

A.9 Documents and Records

The SWQB Project Officer will make copies of this approved QAPP and any subsequent revisions available to the Project Manager. The Project Manager will distribute to all other individuals on the distribution list who do not have signature authority for approving the QAPP. The Project Manager will distribute relevant documentation to other team members as appropriate. The SWQB WPS will retain project documents in accordance with applicable sections of New Mexico's Disposition of Public Records and Non-Records regulation, codified at 1.13.30 Administrative Code (NMAC) and Retention and Disposition of Public Records regulations, codified at 1.21.2 NMAC.

When changes affect the scope, implementation, or assessment of the outcome, this QAPP will be revised to keep project information current. The SWQB Project Officer, with the assistance of the QAO, will determine the effects of any changes to the scope, implementation, or assessment of the outcome on the technical and quality objectives of the project. This Project Plan will be reviewed annually by the Project Manager to determine the need for revision. Project documents include this QAPP, field notebooks, calibration records, validation and verification records, recorded field data, records of analytical data in hard copy or in electronic form, and QC records. Also included are project interim and final reports. Data captured on a global positioning system (GPS), camera, smart phone, tablet, or laptop will be downloaded to Seth Mangini's computer or an external hard drive at the end of each day where it will be backed up to a cloud-based Dropbox folder. At the end of each year, it will be copied and permanently stored on the Philmont Scout Ranch corporate server owned and maintained by the BSA (designated as \M and \S drives in Philmont BSA network). Copies will be made of all data and stored separately from the original data.

All digital project data will be kept in a project file on a Seth Mangini's computer and on a separate external backup hard drive at the Philmont Scout Ranch Conservation office. Hard copy project documents will be kept in a project folder in a secure location at the Philmont Scout Ranch Conservation office and in Seth Mangini's office. All hard copy documents will be digitized and stored on Seth Mangini's computer and backup hard drive (see Table 5). Copies of the data will be distributed by Seth Mangini to NMED SWQB Project Officer after each filed season, typically at the end of each calendar year.

Table 6. Data Records for the Project

Document	Type of Form	Storage Location	Field Sheet Used
QAPP	Electronic (.doc) & Hard Copy	Electronic: SWQB File Depot, Mangini computer, Dropbox, Philmont corporate server Hard: Philmont Conservation Office, Mangini office	EPA Requirements for Quality Assurance Project Plan. EPA QA/R-5. Located at: https://www.epa.gov/sites/production/files/2016-06/documents/r5-final_0.pdf
Calibration Records	Electronic (.doc) & Hard Copy	Electronic: Mangini computer, Dropbox, Philmont corporate server Hard: Philmont Conservation Office, Mangini office	NA
Stream Gauge Data	Electronic (.xls, HOBOware files) Hard Field notebooks	Electronic: Mangini computer, Dropbox, Philmont corporate server Hard: Philmont Conservation Office, Mangini office	NA
Weather Station Data	Electronic (.xls, HOBOware files)	Electronic: Mangini computer, Dropbox, Philmont corporate server	NA
Thermograph Deployment Form	Hard Copy	Philmont Conservation Office, Mangini office	Thermograph Deployment Form. Located at: https://www.env.nm.gov/surface-water-quality/
Temperature Data	Electronic .xls and HOBOware files	Mangini computer, Dropbox, Philmont corporate server	NA

Temperature Effectiveness Analysis	Electronic Excel Macro files	Mangini computer, Dropbox, Philmont corporate server	ANCOVA & Thermograph Excel forms. Available from Dan Guevara, NMED SWQB.
Physical/geomorphic measurements (cross-sectional measurements, longitudinal profile measurements, plan-form measurements, and pebble count)	Electronic (.xls) & Hard Copy	Electronic: Mangini computer, Dropbox, Philmont corporate server Hard: Philmont Conservation Office, Mangini office	Rosgen Level II field sheets and field notebook
Percent canopy cover	Electronic (.xls) & Hard Copy	Electronic: Mangini computer, Dropbox, Philmont corporate server Hard: Philmont Conservation Office, Mangini office	Physical Habitat Field Forms. Located at https://www.env.nm.gov/surface-water-quality/sop/
Sonde Deployment Form	Hard Copy	Philmont Conservation Office, Mangini office	Sonde Deployment form. Located at https://www.env.nm.gov/surface-water-quality/sop/
Sonde Data	Electronic (.xls)	Mangini computer, Dropbox, Philmont corporate server	NA
Photos	Electronic (.jpg)	Mangini computer, Dropbox, Philmont corporate server	Permanent Phot Point Record. Appendix I *"Let the Water do the Work"*
Water Quality Sampling Data	Electronic (.xls), PDF (from lab), Hard Copy Field notebooks	Electronic: Mangini computer, Dropbox, Philmont corporate server Hard: Philmont Conservation Office, Mangini office	NA
Remote Sensing Data (Satellite, aircraft, drone)	Electronic (.jpg, .tiff)	Electronic: Mangini computer, Dropbox, Philmont corporate server	NA
Groundwater well data, Electric Resistivity Data	Electronic (.pdf, .jpg, .stg files) Hard	Electronic: Mangini computer, Dropbox, Philmont corporate server	NA

	Field notebooks	Hard: Philmont Conservation Office, Mangini office	
STEPL Modelling Data	Electronic (.xls)	Mangini computer, Dropbox, Philmont corporate server	STEPL Modelling Spreadsheet, available from NMED
Interim and Final Reports	Electronic (.doc) & Hard Copy	Mangini computer, Dropbox, Philmont corporate server Philmont Conservation Office, SWQB File Depot	NA

GROUP B: DATA GENERATION AND ACQUISITION

B.1 Sampling Design

Sampling design for each parameter will comply with the project Sub-Grant Agreement, extant permits (404/401, NWP 27), best practices (BP), standard EPA methods, and procedures in this QAPP. Sampling data will be used to determine the success in achieving the Measures of Success (Sub-Grant Agreement N. p. 31):

1.) Water Quality
2.) Increase in base-flow
3.) Increase in canopy cover of woody riparian species (willow/alder)
4.) Raised Water Tables in Rehydrated Wetlands
5.) Increase in obligate wetland species in restored wetland areas
Additional metrics of success are to stop erosion at headcuts and to provide functional lift of stream bed in certain reaches (where BDAs will be installed).

All monitoring/sampling activities will be performed by Seth Mangini or other trained Philmont personnel. The project will utilize a sampling run to conduct chemical water quality sampling. A sampling run is considered a period of time used to define the most common collecting period or grouping of sampling activities where project personnel and equipment remain constant. Typically, most samples are collected during multi-day collection events that depart and return to the office in a given week (M-F). The project will collect water quality samples and instantaneous (grab) sonde measurements at least pre- and post-restoration above and below restoration site for assessment unit (AU) 2305.1.A_20. Sample size will meet the minimum requirements (minimum of at least 4 samples per assessment unit) listed in the SWQB CALM so that data can be considered for assessment against New Mexico water quality standards. SWQB generally defines AUs through various factors such as hydrologic or watershed boundaries, water quality standards (WQS) found in 20.6.4 NMAC, geology, topography, incoming tributaries, surrounding land use/land management, etc. AUs are intended to represent surface waters with assumed homogenous water quality. One sampling site has already been determined (Fig. 4) at the location of the Bonito Creek stream gauge. This site will host a deployed sonde during the project to monitor real time water quality from May – Oct./Nov. each year. A second sonde will be used for spot measurements at other sampling locations and to verify calibration on the in-situ sonde. The sampling locations will be determined in the field by the Project Manager, if needed the Project manager will consult the NMED SWQB Project Officer. Instantaneous (grab) sonde measurements include the collection of temperature, conductivity, turbidity, dissolved oxygen, and pH/ORP

If the sampling sites become inaccessible on scheduled sampling dates (i.e. – due to severe weather conditions or other unforeseen events) sampling will be conducted as soon as feasible following that date.

Chemical water quality samples collected in AU 2305.1.A_20 will be analyzed at an accredited laboratory for E. coli, total phosphorus, nitrate, nitrite, and TKN at the minimum. If resources allow water quality samples will also be analyzed for ammonia, cations (metals), dissolved organic carbon, anions (Cl and SO4), electrical conductivity, turbidity, alkalinity, total dissolved solids, and total suspended solids.

The SWQB plans to conduct water quality sampling in Rayado Creek in 2023-2024 according to the 10-Year Monitoring and Assessment Strategy (NMED/SWQB 2016) and should include at least one (1) of the SWQB monitoring stations identified in Table 4. This data may be used to support project objectives.

Stream gauge data, water temperature data, weather station data, and sonde data will be downloaded from equipment at least every month during the project season. Stream velocity measurements will be taken at varying water flow levels equivalent to each cm on the stream gauge staff for calibration of stream gauge measurements.

Initial physical (geomorphic) measurements (cross sections, longitudinal profiles, plan form measurements and pebble count) and photopoints will be conducted in compliance with the issued NWP 27 and will be completed in 2022. Geomorphic measurements will be redone in 2024. Photopoints will be retaken annually. If resources allow, percent canopy will be collected at restoration sites where vegetation may be planted.

Water well data will be taken every two weeks from June – October and electric resistivity (ER) tomography transects will be completed pre- and post-restoration in the two selected reaches (6 and 8 per Restoration Plan).

Remote sensing data (public satellite/aircraft data and drone data) for vegetation analysis and topographic analysis will be taken pre- and post-treatment.

If the minimum frequency and number of water quality sampling sites needs to be changed the Project Manager will consult with NMED Surface Water Quality Bureau (SWQB) Project Officer as soon as practical to ensure project goals can still be met.

Table 7. Project Monitoring Specifics

Responsible Party	Monitoring	Location	Frequency
Seth Mangini, Philmont Staff	Chemical water quality sampling, instantaneous sonde measurements, and field test kits	Bonito stream gauge + others TBD	pre- and post-restoration, minimum
Seth Mangini, Philmont Staff	Water quality (sonde/sensors)	Bonito stream gauge + others TBD	May – Oct./Nov. during project duration

Seth Mangini, Philmont Staff	Physical (geomorphic) measurements	Delineated in NWP 27	2022, 2024
Seth Mangini, Philmont Staff	Water well, ER data	Reaches 6 and 8 (see Restoration plan)	2 weeks (wells) Pre- and post-restoration (ER)
Seth Mangini, Philmont Staff	Photopoints	At each of the structures and other planned treatments	Annually
Seth Mangini, Philmont Staff	Percent canopy	At each of the structures and other planned treatments if resources allow	Pre- and post-restoration
Seth Mangini, Philmont Staff	Remote sensing (vegetation and topography)	Whole watershed (vegetation), BDA reaches (drone)	Pre- and post-restoration

B.2 Sampling Methods

Water Quality Sampling will be conducted in accordance with applicable sections of SWQB SOP 8.2, *Chemical Sampling in Lotic* Environments (NMED/SWQB, 2022b). The applicable sections for this project are: Quality Control Samples, Collecting Water Samples, Sample Collection and Processing for Specific Parameters, Quality Control Activities, and Handling, Packaging and Transporting Samples. Chemical analysis focusing on nutrients and other major water chemistry parameters (Table 8) will be conducted by 1.) sending samples to a water quality laboratory (Hall Environmental Analysis Laboratory (HEAL) in Albuquerque, NM or equivalent accredited laboratory), by 2.) analyzing samples in the field with wet chemical methods (Table 9), and by 3.) utilizing sondes deployed in-situ and for spot measurements. Samples analyzed by laboratory will utilized laboratory provided containers that contain the proper preservative for analyte analyses.

E. coli and coliform sampling will be conducted in accordance with SWQB SOP 9.1 Bacteriological Sampling (NMED/SWQD, 2020) which uses IDEXX Laboratories, Inc. Colilert® method at the SWQB laboratory. If travel time to this laboratory exceeds sample holding time and makes this method impractical then analysis at Hall Environmental or equivalent accredited laboratory using EPA methods (Table 8) may be substituted.

Table 8. Laboratory Analysis Specifics

Analyte	EPA Method	Sample Size/Container	Hold Time	Hold Temperature
E. coli, total coliform	SM9223B	120mL HDP + sodium thiosulfate	8-hour (enumeration) 30-hour (presence/absence)	<10°C
Nutrients (aqueous)	300.0	HDP + conc. sulfuric acid to a pH < 2	28 days	<6°C
Total Kjeldahl Nitrogen (TKN)	SM4500-NorgC	HDP + conc. sulfuric acid to a pH < 2	28 days	<6°C

Ammonia	SM4500-NH3 B+C	HDP + conc. sulfuric acid to a pH < 2	28 days	<6°C
Cations (metals)	200.7/6010B/6010C ICP Metals or 200.8/6020 ICPMS Metals	HDP + conc. Nitric acid to a pH < 2	28 days	Not applicable
Dissolved Organic Carbon (DOC)	9060	HDP	28 days	<6°C
Anions (aqueous) (Includes Cl and SO4)	300.0	HDP	7 days if TSS included; otherwise 14 days.	<6°C
pH	SM4500-H+B/9040C	HDP	as soon as practical	<6°C
Electrical Conductivity	SM2510B	HDP	48-hour	<6°C
Turbidity	180.1	HDP	48-hour	<6°C
Alkalinity	SM2320B	HDP	14 days	<6°C
Total Dissolved Solids (TDS)	SM2540C	HDP	7 days if TSS included; otherwise 14 days.	<6°C
Total Suspended Solids (TSS)	SM2540D	HDP	7 days	<6°C

HDP- high density polyethylene

Table 9. Field chemistry with test kits/electronic probes from Hach

Analyte	Kit Model	Range	Resolution	Method
Nitrogen, Ammonia*	NI-8	0 – 3.0ppm	0.1ppm	Color disc, Nessler reagent
Alkalinity**	Test Kit, Model AL-DT	10 – 4000ppm	0.1	Digital titrator Phenolphthalein
pH	Pocket Pro 9532000	0.00 – 14.00 pH	0.01 pH	Electronic probe
Conductivity/TDS/Salinity	Pocket Pro 9532700	0.0 to 199.9 µS/cm 200 to 1999 µS/cm	0.1 µS/cm 1 µS/cm 0.01 mS/cm	Electronic probe

		2.00 to 19.99 mS/cm		
*Acceptability of results dependent on ammonia concentration and pH (see NM WQSs for Interstate and Intrastate Surface Waters). If parameters out of range results will not be utilized and laboratory analysis will be used.				
** Method accepted for wastewater. Results will be used for wetland classification and not water quality analysis.				

This project will utilize two In-Situ Aqua TROLL 600 Multiparameter Sondes. Sondes will be deployed at monitoring locations in accordance with the SWQB SOP 6.2 *Sonde Deployment* (NMED/SWQB, 2018). Sonde Deployment protocol will follow the Step-by-step Process section identified in SWQB SOP 6.2 and will gather instantaneous (grab)measurements in accordance with section pertaining to Instantaneous Measurements (All Units). Sondes will measure the following parameters: temperature, conductivity, turbidity, dissolved oxygen, and pH/ORP. Other sensors such as nitrate may be substituted if deemed advantageous to project goals.

Stream flow will be collected with a Marsh McBirney FlowMate 2000 or equivalent. Stream flow will be collected in accordance with SWQB SOP 7.0, *Stream Flow* Measurement (NMED/SWQB, 2022c). A HOBO pressure/temperature (Onset HOBO U20L-04) transducer has been attached to the streambed at the gauging station since September of 2020. Measured flow values will be calibrated to the measured pressure from the stream bottom gauge. Data with the Marsh McBirney probe will be validated using the conductivity method (Moore, 2005) because the velocity of small streams is difficult to measure with flowmeters. Both conductivity and the Marsh McBirney will be used to validate a new method of stream flow measurement method being developed for this project which uses a non-toxic dye to measure flow velocity visually, by measuring the time required for the plume to move between two monuments set 10m apart.

Temperature and precipitation for the Bonito Creek watershed are being monitored via an Onset HOBO (RG3) datalogging weather station since September of 2020. A power free anti-freeze snow melting system (manufactured by Texas Electronics) is attached during the winter months. Temperature and precipitation data will be used to monitor how quickly precipitation affects stream flow as measured by the Bonito Creek stream gauge.

Temperature data loggers (HOBO Pendant MX2201 or MX2202 or equivalent) will be deployed at monitoring locations in accordance with the SWQB SOP 6.3 *Temperature Data* loggers (NMED/SWQB, 2019b). Temperature data logger deployment will follow all applicable sections of the SWQB SOP for *Temperature Data loggers* which includes the QAQC section.

Physical (geomorphic) measurements will be conducted according to Rosgen Level II surveys. The following surveys will be used for this project cross sections, longitudinal profiles, plan form measurements and pebble count)

Percent canopy cover data will be conducted in accordance with SWQB SOP 5.0. *Physical Habitat Measurements* (NMED/SWQB, 2019). All applicable sections of SWQB SOP 5.0 will be adhered to during data collection for percent canopy.

Photographic documentation will be conducted using a modified version of the protocols identified in *Let the Water Do the Work* (Zeedyk, et al, 2009) Appendix I, Outline for Photographic Monitoring Plan. Photo points will be recorded using Permanent Photo Point-Record-Initial Take (Form 1). Photopoints will be marked with a permanent monument and the coordinates recorded in the project GIS dataset. Repeat photographs will be taken in the same directions and the photo saved in the project database. A dry erase board or sheet including the photopoint ID, date, time, and photographer will be included in the photo frame.

STEPL modeling will be done in accordance with the instructions provided by the US EPA (EPA, 2020). WEPP modelling will be conducted in accordance with USDA Forest Service methods (Elliot, 2013). Input data will be collected during the project and/or sourced from 1m resolution lidar derived DEM's from the USGS National Map.

Monitoring wells will consist of 5-foot (152.4cm) sections of 2.5" (6.4cm) PVC pipe installed vertically into the ground with 2" (5cm) of pipe remaining above ground. Wells will be spaced along valley cross sections with 4-5 wells per cross section. Measurements to water depth will be conducted manually with a tape measure. Cross sections will also serve as electric resistivity transects.

ER tomography will be used to measure the distribution of groundwater before and after restoration treatments in two reaches (6 and 8) of wetland which are to be restored using "mini-beave" water spreading structures (see Restoration Plan and NWP 27). ER transects will be tied to monitoring wells to validate groundwater data. The ER system to be used is an AGI SuperSting array with 24 electrodes which can be spaced up to 4m apart, providing measurements of up to 30m in depth. Data is processed using AGI 2D Earth Imager software which creates cross sections sediment and groundwater distribution based on measured resistance between pairs of electrodes (Fig. 7). Methods can be found in Riwayat et al., 2018.

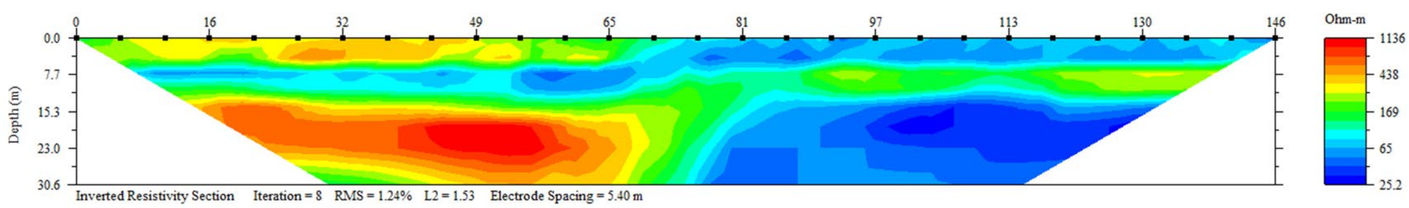


Figure 7. – Example if electric resistivity transect. Blue indicates higher conductivity mediums such as saturated sediments and red lower conductivity dry sediments.

Vegetation response monitoring will be conducted using remotely sensed, publicly available data using published methods for analysis of vegetation monitoring (Fairfax and Small, 2018; Hausner et al., 2018; Silverman et al., 2019). These methods use Landsat imagery to evaluate Normalized Difference Vegetation Index (NDVI) and plant transpiration for stream restoration projects. We propose to use this same methodology with the higher resolution NAIP imagery taken by the US Farm Bureau every two years (typically in late June). Riparian canopy cover is close to 0% over most of the watershed apart from Reach 7 (see Restoration Plan and NWP 27). Canopy cover in this reach can be quantified by tracing polygons over willow covered areas. These results may be validated using on the ground transects with a spherical crown densitometer if deemed desirable. Recovery of willows to a canopy state in other reaches will not occur during the time frame of Phase I, but plantings and natural regeneration will be mapped with GIS.

Drone imagery (using a DJI Mavic Air 2 drone) will be used to make high resolution digital elevation models (DEMs) of selected reaches of the valley bottom using structure from motion software Agisoft Metashape (available through Montana State University). DEMs will be created before and after the construction of BDAs used to measure the volume of surface water stored by BDA's.

B.3 Sample Handling and Custody

Sample handling and custody will be done is accordance with SWQB SOP 8.2, *Chemical Sampling in Lotic Environments* section pertaining to Handling, Packaging and Transporting Samples. All water samples which will be transported for external laboratory analysis within time limits and temperature requirements required by laboratory and EPA methods.

B.4 Analytical Methods

All chemical analytical methods will utilize methods approved by NMED/SWQB and the EPA (Table 8) or field-based methods (Table 9) approved in this QAPP.

B.5 Quality Control

Quality control (QC) activities are technical activities performed on a routine basis to quantify the variability that is inherent to any environmental data measurement activity. QC activities are routinely performed, not to eliminate or minimize errors, but to measure or estimate their effect. The purpose for conducting QC activities is to understand and incorporate the effects the variability may have in the decision-making process. Additionally, the results obtained from the QC analysis, or data quality assessment, may identify areas where the variability can be reduced or eliminated in future data collection efforts, thereby improving the overall quality of the project being implemented.

Quality Control mechanisms are implemented as described under the Quality Objectives and Criteria for Measurement Data as well as the sampling methodologies identified under this QAPP. Additional Quality Control includes the professional expertise of the personnel working under this project.

Electronic instruments (Sondes, electronic pH and conductivity meters) will be tested against standards prior to each use. The portable sonde will be used to check the calibration of the deployed sonde (at least once per month). The accuracy of laboratory analyses will be checked by sending blanks (nanopure water ≥18MΩ*cm) and purchased standards laboratory along with samples. Blanks will be included for analysis at the rate of 10% of the total field samples collected for sampling run when analysis includes E. coli, nutrient, TSS, TDS, Cl, and SO4 as required by the SWQB the quality assurance requirements. Blanks associated with a sampling run are assumed to represent a group of samples collected by the same staff, and using the same equipment, vehicle, reagents, and acids. When multiple, single day sampling runs are conducted within a given week that maintain constant variables as described above, the single day sampling runs are considered collectively as a single sampling run, provided that the number of blanks collected is at least 10% of the environmental samples collected, preferably at a one blank sample per ten ambient sample frequency to allow for quality control blank distribution. Field test kit accuracy will be tested with blanks and standards. Other QC control measures include sending duplicate samples to lab and conducting multiple (≥3) analyses of the same sample with test kits to quantify uncertainty.

B.6 Instrument/Equipment Testing, Inspection and Maintenance

Batteries for all field deployed instruments (HOBO temperature and pressure transducers, In-Situ sondes), HOBO weather station, will be checked at the beginning of each field season (May) and again at the close of each field season (October or November). Data from these instruments will be downloaded at least once per month during the field season. Spare pressure transducers/temperature sensors will be kept on hand to replace any which may become damaged or removed from field sites. Transducers will be replaced after two years of service.

At the beginning of winter, the snow melting attachment will be installed on the weather station. Data will be downloaded once per month and levels anti-freeze and mineral oil will be kept at functioning levels in accordance with manufacturer's instructions. These tasks will be carried out by Mangini or other designated Philmont employees.

B.7 Instrument/Equipment Calibration and Frequency

All data should be collected with monitoring devices that can be shown to have been properly calibrated. For this project, specific calibration requirements apply to In-Situ Aqua TROLL 600 Multiparameter sondes, Pocket Pro 9532000 Conductivity/TDS/Salinity meter, Pocket Pro 9532700 pH meter, AGI Super-Sting Electric Resistance Tomography instrument, and HOBO weather station temperature-precipitation gauge. The Pocket Pro meters and the sonde which will be used for calibration and spot measurements will calibrated prior to each sampling run and the calibration checked at the end of the run, in accordance with SWQB SOP 6.1 (2021). The calibration of the in-situ sonde will be verified at least once per month during field deployment using the portable sonde. The HOBO weather station and AGI Super Sting will have calibration checked annually using the methodology described in the manufacturer's instructions. The calibration of temperature sensors on the sondes and HOBO probes will be verified against a NIST thermometer in accordance with SWQB SOP 6.3 (2019). Documentation of calibration and verification will be maintained by Seth Mangini and stored in accordance with the data management procedures delineated in Section A 9.

B.8 Inspection Inspection/Acceptance for Supplies and Consumables

All necessary consumables (sampling bottles, standards, blanks, PPE, etc.) will be kept on hand in adequate quantities. Any defective consumables or other equipment (sensors, laser levels, etc.) will not be used and replacements found if possible.

B.9 Non-direct Measurements

Existing Landsat images from NASA (National Aeronautics and Space Administration), will be used to evaluate changes in vegetation resulting from restoration. NAIP (National Agriculture Imagery Program) imagery from the USDA Farm Service Agency will also be used for this analysis. If other, better suited equivalent datasets are discovered or become available these analyses may utilize them as well.

Data inputs for STEPL model will be collected during this project or be taken from publicly available DEMs (from the USGS National Map) that already exist. They will be 1m resolution lidar derived DEMS that have undergone the agencies quality assurance requirements.

An initial evaluation of Bonito Creek was conducted from 2010 – 2015 and the concept of a restoration project was conceived during this time. The data and reports created from 2010-2015 may be used during the course of the current project as well as the restoration design planning completed in 2020 by Seth Mangini for his PhD project.

B.10 Data Management

Seth Mangini will be responsible for data management. All data will be converted to electronic format, stored, and backed up by Seth Mangini in compliance with Element A9. Computer hard drives will be backed up to a cloud-based Dropbox folder. Hard copies of field sheets will be maintained in a project binder organized by assessment and date and stored in a key protected filing cabinet in the office of Philmont Scout Ranch Conservation Department.

Data will be sent to the SWQB Project Officer at the end of each field season by Seth Mangini (typically by the end of November). Upon receiving data, the SWQB Project will store data on SWQB network drive in a project specific folder. The SWQB will retain project documents in accordance with applicable sections of New Mexico's Disposition of Public Records and Non-Records regulation, codified at 1.13.30 New Mexico Administrative Code (NMAC) and Retention and Disposition of Public Records regulations, codified at 1.21.2 NMAC.

GROUP C: ASSESSMENT AND OVERSIGHT

C.1 Assessment and Response Actions

The Project Officer will provide project oversight by periodically assisting with and/or reviewing data collection efforts. A review of the baseline data collection and monitoring efforts by the SWQB Project Officer will take place at the end of each monitoring season. The SWQB Project Officer will assess project progress to ensure the QAPP is being implemented, including periodic audits by the QAO, as needed. Any problems encountered during the course of this project will be immediately reported to the SWQB Project Officer who will consult with appropriate individuals to determine appropriate action. Should the corrective action impact the project or data quality, the SWQB Project Officer will alert the QAO. If it is discovered that monitoring methodologies must deviate from the approved QAPP, a revised QAPP must be approved before work can be continued. All problems and adjustments to the project plan will be documented in the project file and included in the final report.

C.2 Reports to Management

Annual and quarterly reports will be submitted by the project manager (Seth Mangini) to the SWQB Project Officer and will include progress of project and any available data. Printouts, status reports or special reports for SWQB or EPA will be prepared upon request. The final report will be submitted to the SWQB Project Officer by June 2024. The SWQB Project Officer will be responsible for submitting the final project deliverables to EPA through their Grants Reporting Tracking System.

GROUP D: DATA VALIDATION AND USABILITY

D.1 Data Review, Verification and Validation

Data will be reviewed by the Project Manager (Seth Mangini) for erroneous data, incomplete data and transcription errors prior to demobilization from the field site. Data will be considered usable if the requirements of this QAPP were followed and the data is within acceptable range limits as defined under this QAPP. Data that appears incomplete or questionable for the parameter will be flagged for review. Flagged data will be discussed with the SWQB Project Officer to determine the potential cause and usability. If a reasonable justification for use of the data cannot be attained, those data will be not used in analysis and implementation of activities listed under this QAPP unless the data can be recollected and assessed for usability.

D.2 Validation and Verification Methods

The Project Manager (Seth Mangini) will ensure that valid and representative data are acquired. Verification of field sampling and analytical results will be performed by the Mangini in accordance with the applicable section of the SWQB SOP 15.0 for *Data Verification and* Validation (NMED/SWQB, 2020b). Verification and validation (V&V) of data will occur after every field season using a slightly modified version of the attached V&V worksheets (Attachments A-1, A-2, and A4). In the event questionable data are found, the SWQB Project Officer will notified and will consult appropriate personnel to determine the validity of the data. Results of the verification and validation process will be included in the final reports.

D.3 Reconciliation with User Requirements

The user requirement is a restatement of the data quality objective: The quality of the data will be adequate to provide a high level of confidence in determining whether the Bonito Meadow Restoration Project Phase I is meeting the project goals, as stated in the approved scope of work.

If the project's results do not meet this requirement, then additional monitoring may be necessary to fill in data, which may include an extension of the monitoring period to measure effects that were not apparent during the project period.

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Acknowledgement Statement

New Mexico Environment Department Surface Water Quality

Bonito Meadow Restoration Project Phase I

Quality Assurance Project Plan Acknowledgement Statement

This is to acknowledge that I have received a copy (in hard copy or electronic format) of the Bonito Meadow Restoration Project Phase I Quality *Assurance Project Plan*.

As indicated by my signature below, I understand and acknowledge that it is my responsibility to read, understand, become familiar with, and comply with the information provided in the document to the best of my ability.

____
Signature

____
Name (Please Print)

____
Date

Return to SWQB Project Officer Emily Toczek

Attachment A-1 Chemical Data Verification and Validation Worksheet

Study Name: _____
Year:____
Project Coordinator:_____
Data covered by this worksheet:_____
Version of Verification/Validation Procedures: _____QAPP

Step 1: Verify Field Data

A. Are all Field Data forms present and complete? ☐ Yes ☐ No
Comments:

B. Are station name and ID, and sampling date and time (ACT_START_DATE) on forms consistent with database? ☐ Yes ☐ No
Comments:

C. Are field data (field staff, collection equipment, media subdivision, sonde readings and flow condition rating) on forms consistent with database? ☐ Yes ☐ No
Comments:

D. Are RIDs correct and associated with the correct analytical suite, media subdivision (e.g., surface water, municipal waste, etc.) and activity type (e.g., Field observation, Routine sample, QA sample etc.)?
☐ Yes ☐ No
Comments:

E. Are lake field data on forms consistent with the database?
☐ Yes ☐ No

F. Are lake profile data on forms consistent with the database?
☐ Yes ☐ No

☐ **Step 1 Completed** ***Initials:*** _____ ***Date:*** _____

- -

Step 2: Verify Flow Data

A. Are all flow measurements correctly transcribed from the field sheet to the Stream Flow Sheet and Calculator or is the flow meter output file complete without data errors? ☐ Yes ☐ No

B. Are all flow forms, flow meter output files, or recorded gage data consistent with the database? ☐ Yes ☐ No

☐ **Step 2 Completed** ***Initials:*** _____ ***Date:*** _____

- -

Step 3: Verify Data Deliverables

A. Have all data in question been delivered? ☐ Yes ☐ No

If yes, proceed; if no, indicate RIDs with missing data (samples or blanks) or attach report with applicable RIDs highlighted. Contact data source and indicate action taken. Complete this step upon receipt of all missing data.

RID	Submittal Date	Missing Data/Parameters	Date of Initial Verification	Date Missing Data Were Received
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Total number of occurrences: _____

B. Do all of the analytical suites have the correct number and type of analytes. ☐ Yes ☐ No

If yes, proceed; if no, indicate RIDs with missing or incorrect analyte(s) or attach report with applicable RIDs highlighted. Contact data source and indicate action taken.

RID	Submittal Date	Missing or Incorrect Parameters	Action Taken	Re-verified?
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

☐ **Step 3 Completed** ***Initials:*** _____ ***Date:*** _____

- -

Step 4: Verify Analytical Results for Missing Information or Questionable Results

Were any results with missing/questionable information identified? ☐ Yes ☐ No

If no, proceed; if yes, indicate results with missing information or questionable results or attach report. Contact data source and indicate action taken. Complete this step upon receipt of missing information or clarification of questionable results (clarify questionable results only, DO NOT change results without written approval (from lab or QA officer) and associated documentation).

RID	Sample Date	Missing or Questionable Information/Results	Action Taken
_____	_____	_____	_____
_____	_____	_____	_____

Total number of occurrences: _____

☐ **Step 4 Completed** ***Initials:*** _____ ***Date:*** _____

- -

Step 5: Validate Sonde Grab Data

Did any sensors fail post check? ☐ Yes ☐ No

If yes, indicate which sensor/characteristic failed and the qualifier code applied for that sampling run (see attached file for large data sets).

STATION ID	***ACT START DATE***	***CHARACTERISTI C NAME***	***REASON FOR QUALIFIER CODE***	***SWQB QUALIFIER CODE***	***QUALIFIER CODE VERIFIED***

☐ **Step 5 Completed** ***Initials:*** _____ ***Date:*** _____

- -

Step 6: Validate Blank Collections

Were required blanks collected? ☐ Yes ☐ No

If yes, proceed; if no, list results from the sampling run that need to have validation codes applied in the database, save these results as an excel file, and forward to the Project Manager, Monitoring Team Supervisor, or Program Manager, with a request to add appropriate validation codes to database. Complete this step after verifying that validation codes have been added to database correctly.

RID	Sample Date	Analytical Suite	Validation Code/Flag Applied	Code/Flag verified in database?
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

☐ **Step 6 Completed** ***Initials:*** _____ ***Date:*** _____

- -

Step 7: Validate Blank Collection Frequency

Were blanks collected at the correct frequency? ☐ Yes ☐ No

If yes, proceed; if no, list results from the sampling run that need to have validation codes applied in the database, save these results as an excel file, and forward to the Project Manager, Monitoring Team Supervisor, or Program Manager, with a request to add appropriate validation codes to database. Complete this step after verifying that validation codes have been added to database correctly.

RID	Sample Date	Analytical Suite	Validation Code/Flag Applied	Code/Flag verified in database?
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

_____	_____	_____	_____	_____

☐ **Step 7 Completed** ***Initials:*** _____ ***Date:*** _____

- -

Step 8: Validate Blanks Results

Were any analytes of concern detected in blank samples? ☐ Yes ☐ No

If no, proceed; if yes, list results that need to have validation codes applied in the database save these results as an excel file and forward to the Project Manager, Monitoring Team Supervisor, or Program Manager, with a request to add appropriate validation codes to database. Complete this step after verifying that validation codes have been added to database correctly.

RID	Sample Date	Parameter	Blank	Sample	Validation Code/Flag Applied	Code/Flag verified in database? *
_____	______	______	______	______		________
______	______	______	______	______		________

*See validation procedures to determine which associated data need to be flagged and include on *Validation Codes Form*.

Total number of occurrences: _____

☐ **Step 8 Completed** ***Initials:*** _____ ***Date:*** _____

- -

Step 9: Validate Holding Times Violations

Were any samples submitted that did not meet specified holding times? ☐ Yes ☐ No

If no, proceed; if yes, list results that need to have validation codes applied in the database save these results as an excel file and forward to QA officer or Program Manager with a request to add appropriate validation codes to database. Complete this step after verifying that validation codes/flags have been added to database.

RID	Sample Date	Parameter	[Blank] Check	[Sample] Check	Validation Code/Flag Applied	Code/Flag verified in database to ALL associated data? *
______	______	______	______	______		________
______	______	______	______	______		________

*See validation procedures to determine which associated data need to be flagged.

Total number of occurrences: _____

☐ **Step 9 Completed** ***Initials:*** _____ ***Date:*** _____

- -

Step 10: Validate Replicate/Duplicate Results (if applicable)

Were any replicate/duplicate pairs submitted outside of the established control limit of 20%? ☐ Yes ☐ No

If no, proceed; if yes, list results that need to have validation codes applied in the database save these results as an excel file and forward to QA officer or Program Manager with a request to add appropriate validation codes to database. Complete this step after verifying that validation codes/flags have been added to database.

RID Pairs		Replicate or Duplicate?	Sample Date	Parameter	RPD	Validation Code/Flag Applied	Code/Flag verified in database applied? *
_____	_____	_____	_____	_____	_____		_______
_____	_____	_____	_____	_____	_____		_______

*See validation procedures to determine which associated data need to be flagged.

Total number of occurrences: _____

☐ **Step 10 Completed** ***Initials:*** _____ ***Date:*** _____

****

After all of the above steps have been completed, save and print the worksheet, attach all applicable supplemental information and sign below.

I acknowledge that the data verification and validation process has been completed for the data identified above in accordance with the procedures described in the SWQB QAPP.

____

Data Verifier/Validator Signature Date

COMPLETION OF DATA VERIFICATION AND VALIDATION PROCESS

Once the data verification and validation process has been completed for the entire study (note: if the worksheet is for a subset of the data from a study, be sure ALL the data for the entire study is included before final completion of the data verification and validation process), notify the NMSQUID administrator that the process is complete and request that “V V in STORET” be added to the project title.

Once all data have been verified and validated for a study provide copies of ALL *Data Verification and Validation Worksheets* and attachments associated with the study to the Quality Assurance Officer and retain originals in the project binder.

Attachment A-2 Physical/Habitat Data Verification and Validation Worksheet

Study Name: _____
Year:____
Project Coordinator:_____
Data covered by this worksheet:_____
Version of Verification/Validation Procedures: _____QAPP

Step 1: Verify Field Data

A. Are all Field Data forms present and complete? ☐ Yes ☐ No
Comments:

B. Are station name and ID, and sampling date and time (ACT_START_DATE) on forms consistent with database? ☐ Yes ☐ No
Comments:

C. Are field data (comments, flow method, field staff, lat/long, average wetted width, pebble count reach length, thalweg reach length and Interval length) on forms consistent with database? ☐ Yes ☐ No
Comments:

☐ **Step 1 Completed** ***Initials:*** _____ ***Date:*** _____

- -

Step 2: Verify Data Transcription

Are data on pebble count, cross section, thalweg, slope and bankful/flow field forms consistent with database? ☐ Yes ☐ No

☐ **Step 2 Completed** ***Initials:*** _____ ***Date:*** _____

- -

Step 3: Validate Replicate Samples

Did all pebble count observers complete one replicate during the field season? ☐ Yes ☐ No

Pebble Count Observer	Pebble Count Replicate Completed (Y/N)	Station Name Where Replicate Occurred
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

If yes, proceed; if no, identify which sampling events were associated with an observer who didn't complete a pebble count replicate. Enter "replicate pebble count not completed" in the sampling event comments for all sampling events completed by that observer.

Station	Sampling Date(s)	Observer
_____	_____	_______
_____	_____	_______

Total number of occurrences: _____

☐ **Step 3 Completed** ***Initials:*** _____ ***Date:*** _____

****

After all of the above steps have been completed, save and print the worksheet, attach all applicable supplemental information and sign below.

I acknowledge that the data verification and validation process has been completed for the data identified above in accordance with the procedures described in the SWQB QAPP.

____

Data Verifier/Validator Signature   Date

COMPLETION OF DATA VERIFICATION AND VALIDATION PROCESS

Once the data verification and validation process has been completed for the entire study (note: if the worksheet is for a subset of the data from a study, be sure ALL the data for the entire study is included before final completion of the data verification and validation process), provide copies of ALL *Data Verification and Validation Worksheets* and attachments associated with the study to the Quality Assurance Officer and retain originals in the project binder.

Attachment A-4 LTD Data Verification and Validation Worksheet

Study Name: _____
Year:____
Project Coordinator:_____
Type of LTD Data Being Verified and Validated: _____
Data covered by this worksheet:_____
Version of Verification/Validation Procedures: _____QAPP

Step 1: Confirm all LTD data has been archived and data has been uploaded
Are all raw data files in the appropriate archive folder and are all field deployment forms complete and match station and study metadata in the database including but not limited to filename, logger start and stop dates, and sampling events? ☐ Yes ☐ No

☐ **Step 1 Completed** ***Initials:*** _____ ***Date:*** _____

- -

Step 2: Verify that all LTD data has been reviewed, truncated to logger start and stop dates and times, and summary statistics generated and accurately recorded in database
Have all LTD data in question been uploaded, attributed, and faithfully transcribed? ☐ Yes ☐ No

☐ **Step 2 Completed** ***Initials:*** _____ ***Date:*** _____

- -

Step 3: Validate LTD Activity Quality
Did any LTD data require qualifier codes? ☐ Yes ☐ No

If no, proceed; if yes, indicate what qualifier was applied and why (see attachment for large datasets).

LTD LOGGER TYPE	***STATION ID***	***ACT START DATE***	***PARAMETER NAME***	***REASON COMMENTS***	***LTD PARAMETER QUALIFIER CODE***	***LTD QUALIFIER CODE VERIFIED (Y/N)***
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____

*****Cannot add qualifiers to minimum, maximum, and average temperature results in SQUID. Added note to deployment event comments.

Total number of occurrences:

☐ **Step 3 Completed**
Initials: _____
Date: _____

****

After all of the above steps have been completed, save and print the worksheet, attach all applicable supplemental information and sign below.

I acknowledge that the data verification and validation process has been completed for the data identified above in accordance with the procedures described in the SWQB QAPP.

____

Data Verifier/Validator Signature Date

COMPLETION OF DATA VERIFICATION AND VALIDATION PROCESS

Once the data verification and validation process has been completed for the entire study (note: if the worksheet is for a subset of the data from a study, be sure ALL the data for the entire study is included before final completion of the data verification and validation process), provide copies of ALL *Data Verification and Validation Worksheets* and attachments associated with the study to the Quality Assurance Officer and retain originals in the project binder.