Hydrologic and Geomorphic Monitoring and Data-sharing in SW Colorado

San Juan Watershed Lunch & Learn
Monday, May 2, 2022

Dr. Gigi A. Richard
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FOUR CORNERS WATER CENTER at FORT LEWIS COLLEGE

FORT LEWIS COLLEGE

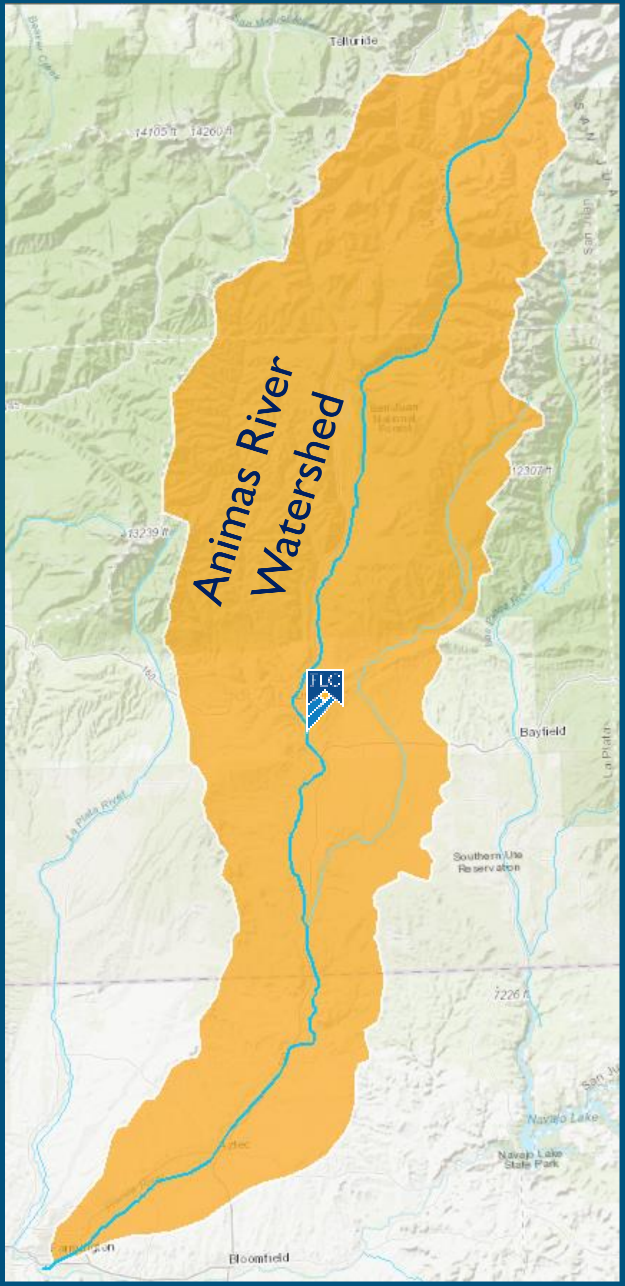
Land Acknowledgement

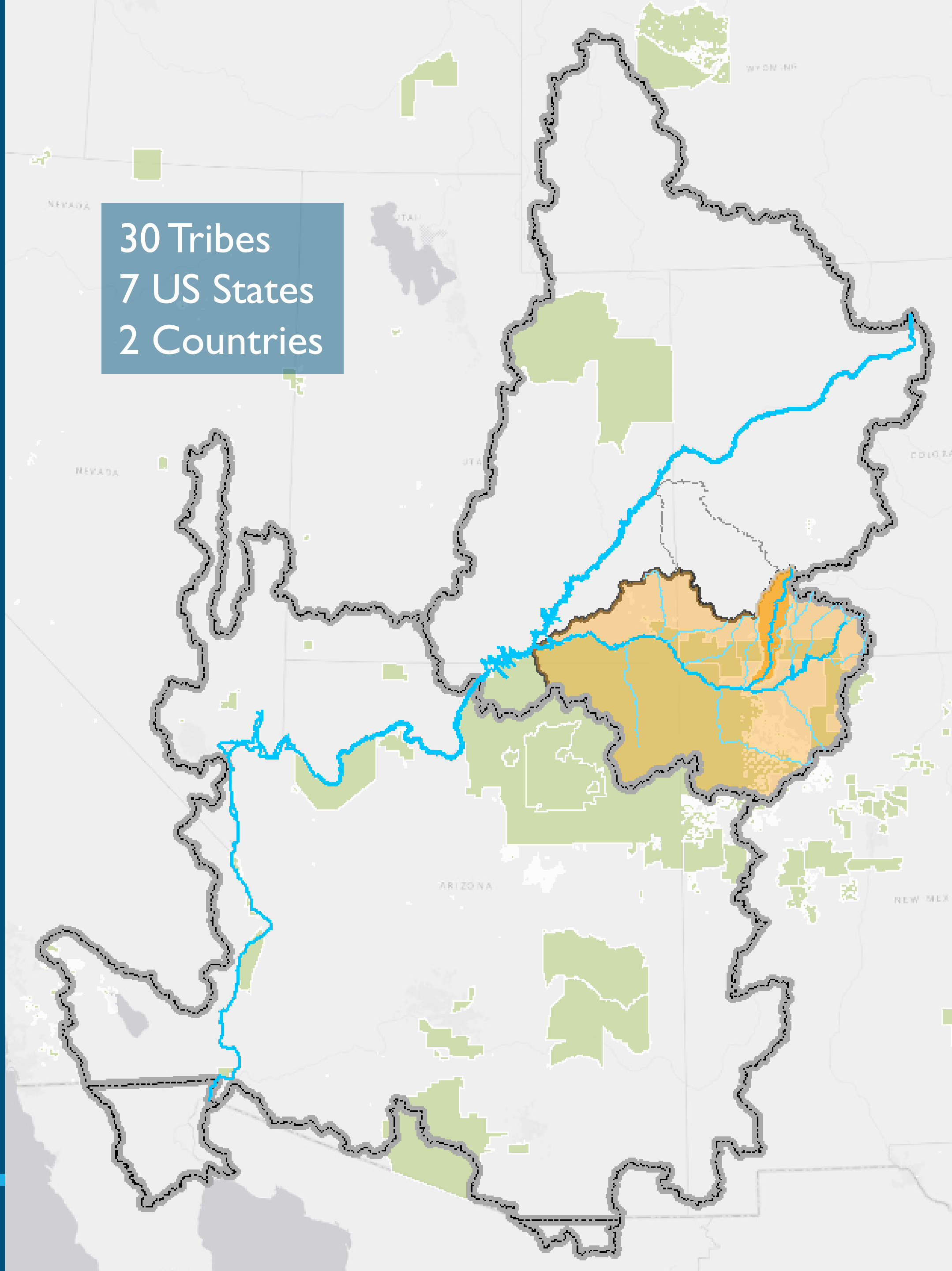
At Fort Lewis College, we honor and respect the land on which we gather.

We acknowledge the land that Fort Lewis College is situated upon is the ancestral land and territory of the Nuuchiu (Ute) people who were forcibly removed by the United States Government. We also acknowledge that this land is connected to the communal and ceremonial spaces of the Jicarilla Abache (Apache), Pueblos of New Mexico, Hopi Sinom (Hopi), and Diné (Navajo) Nations.

It is important to acknowledge this setting because the narratives of the lands in this region have long been told from dominant perspectives, without full recognition of the original land stewards who continue to inhabit and connect with this land.

Thank you for your respect in acknowledging this important legacy.





Water is Life.

We are all 2/3 water.

Water connects us.

FOUR CORNERS WATER CENTER
at FORT LEWIS COLLEGE®

…an interdisciplinary center dedicated to contributing to solutions to our water challenges

What we do…

- Cultivate the next generation of water leaders
- Collaborate with regional inform and engage students and the public with regional water issues and solutions
- Provide a hub for water data and information

FourCornersWater.org

Collaborative watershed monitoring between CSU, FLC & CMU












Dr. Stephanie Kampf, Watershed Science
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Kira Puntenney-Desmond

Colorado State University
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Shinya Burck, 2020, Biology
Hozhoo Emerson, Geosciences
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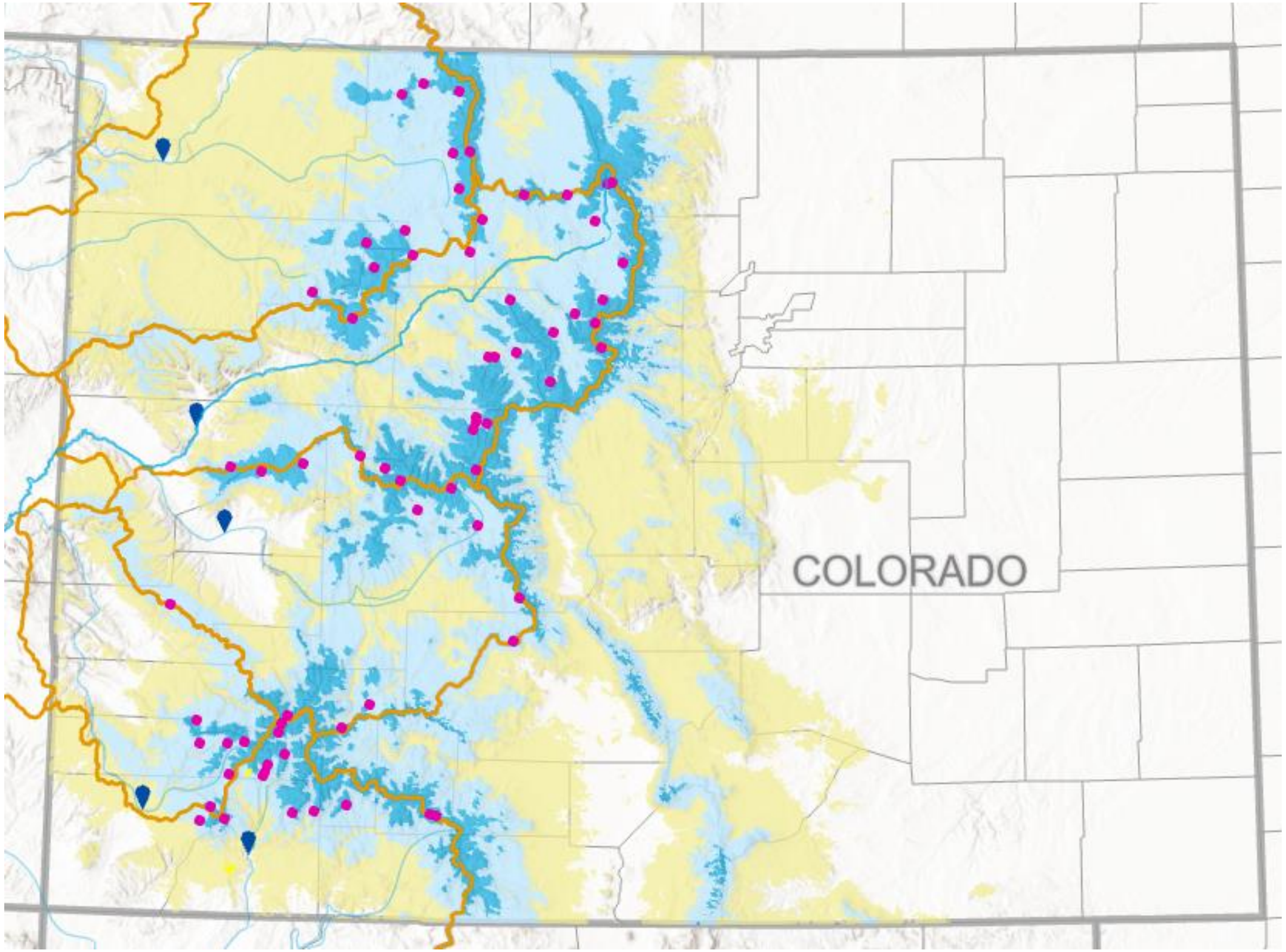
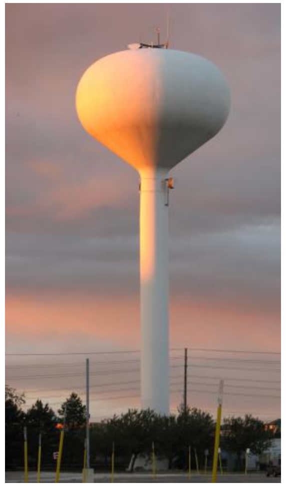
Craig Moore, 2017, Environmental Science
Jordan Veith, 2018, Environmental Science
Ivan McClellan, 2018, Geology
Matt Stewart, 2018, Environmental Science

COLORADO MESA UNIVERSITY

Colorado's Snowpack is Colorado's water tower





Persistent snow zone

Transitional snow zone

Intermittent snow zone

SNOTEL Stations

Stream gages

Snow zones are defined by Jan-Jun snow persistence (SP). Low snow has mean annual (2000-2017) SP <0.25; intermittent snow has 0.25<SP<0.50; transitional snow has 0.5<SP<0.75, and persistent SP>0.75.

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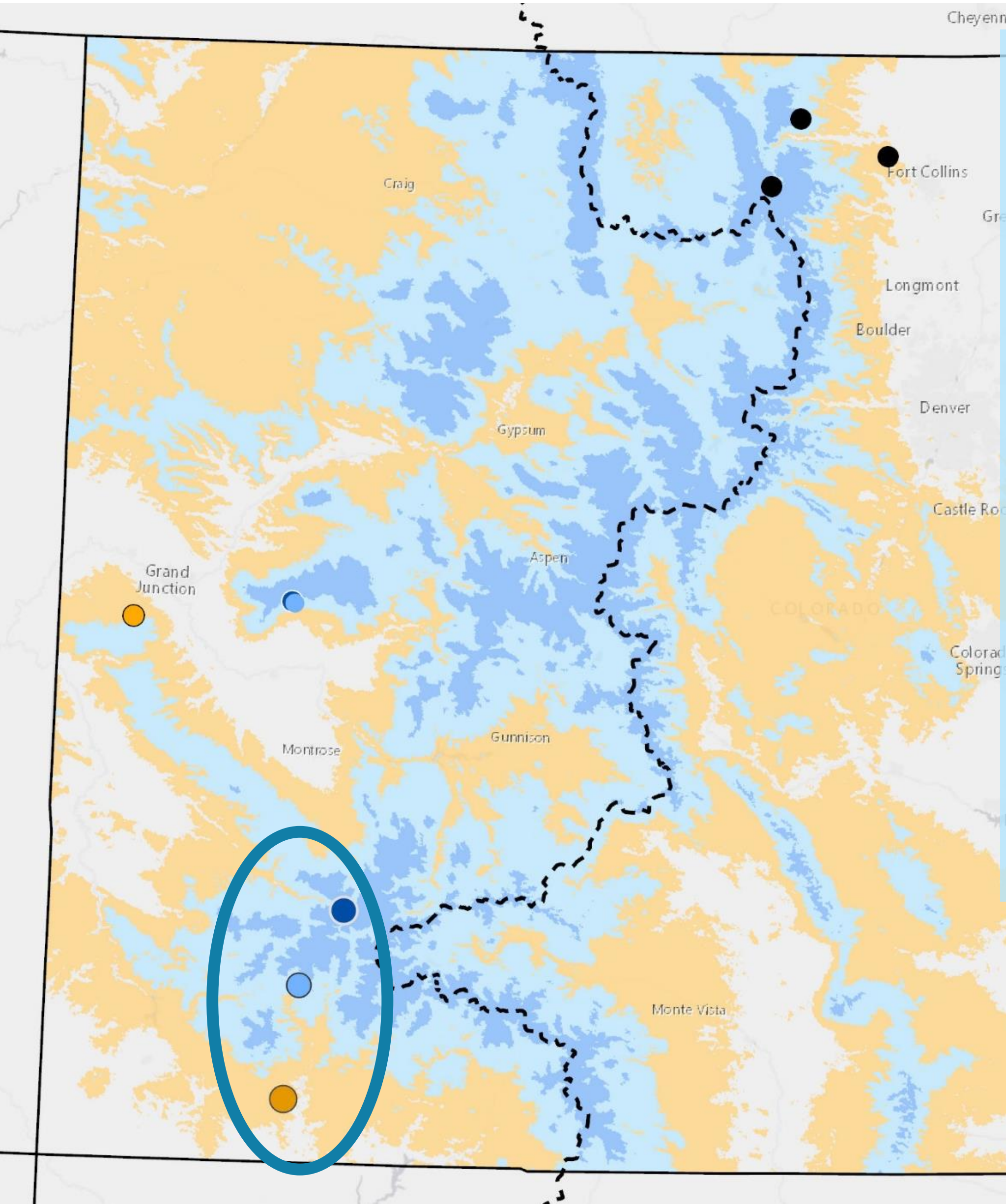
Snow persistence data from Hammond & Kampf

Monitoring snowpack and streamflow



persistent
transitional
intermittent

Persistent – Senator Beck
Avg. elev. = 12,300 ft

Transitional – Relay Creek
Avg. elev. = 10,400 ft

Basin Creek - Intermittent
Avg. elev. = 7,360 ft

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Monitoring network

Installation

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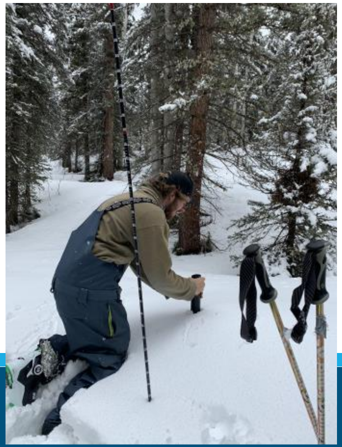
Monitoring network

Tipping bucket rainfall gauge

Weighing bucket precipitation gauge

Precipitation

Snow density cores for SWE



Monitoring network

Streamflow

Soil moisture & temperature

Air temperature & relative humidity

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Monitoring network

Wildlife!

Monitoring network

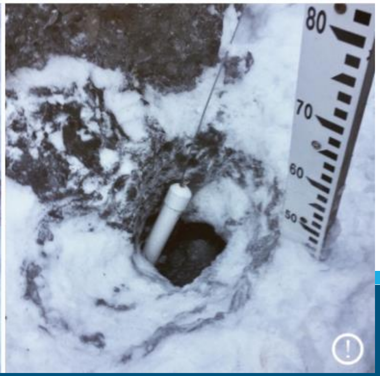




Snow & Ice Challenges



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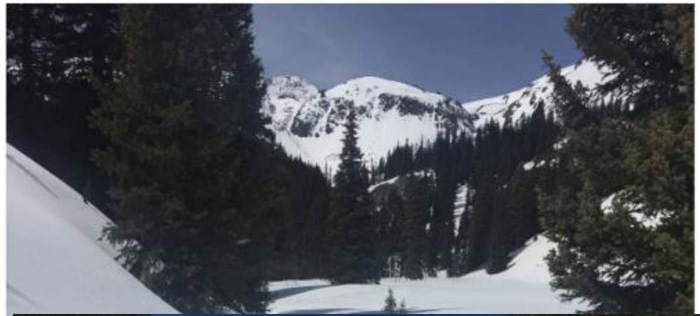
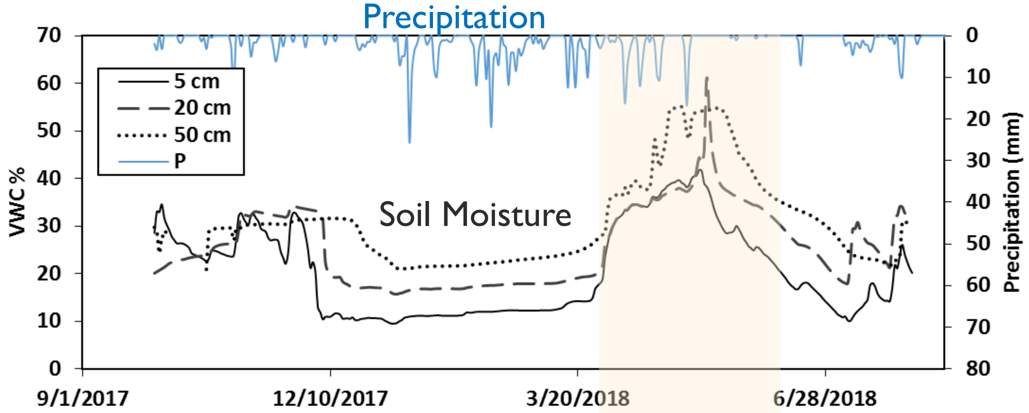
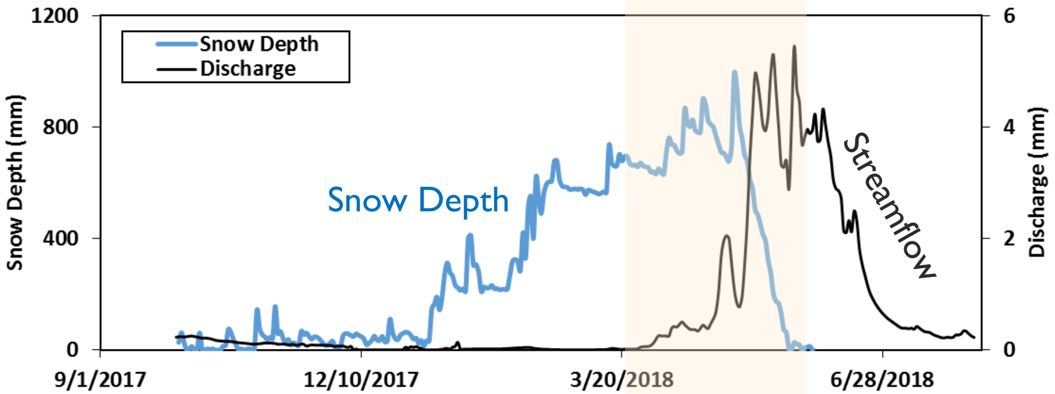
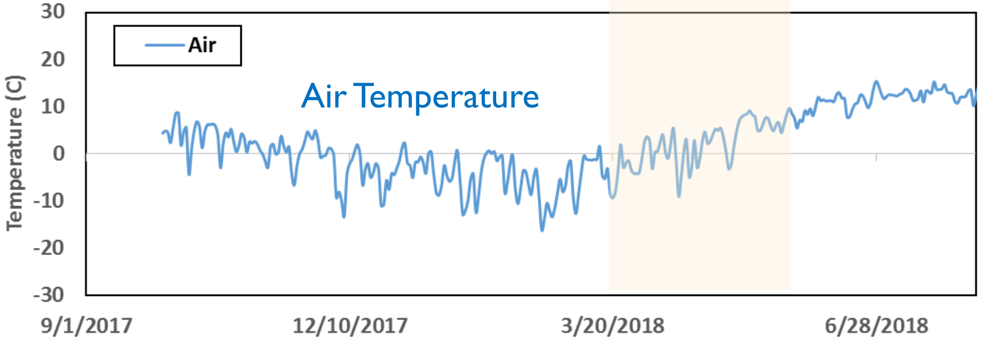
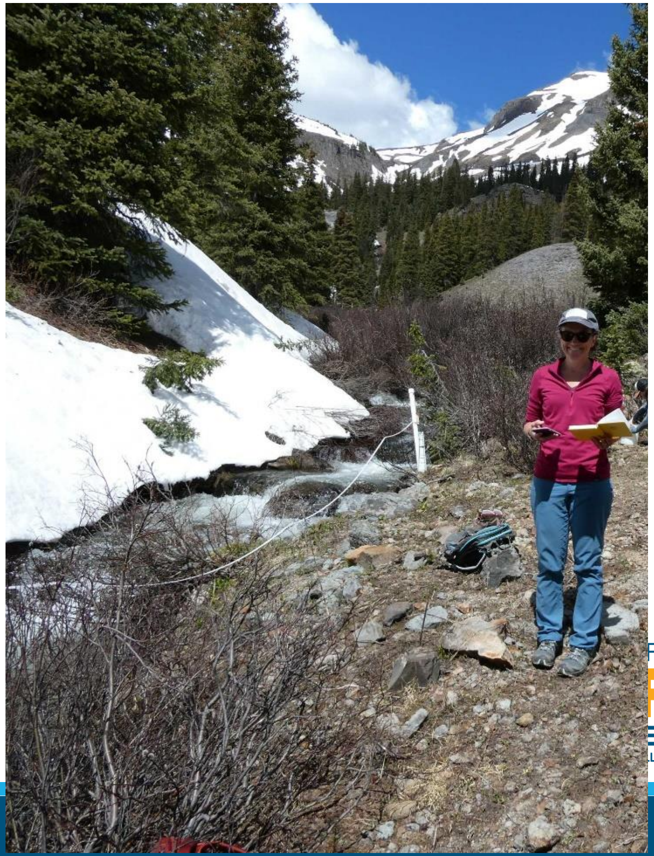
Senator Beck Basin Example







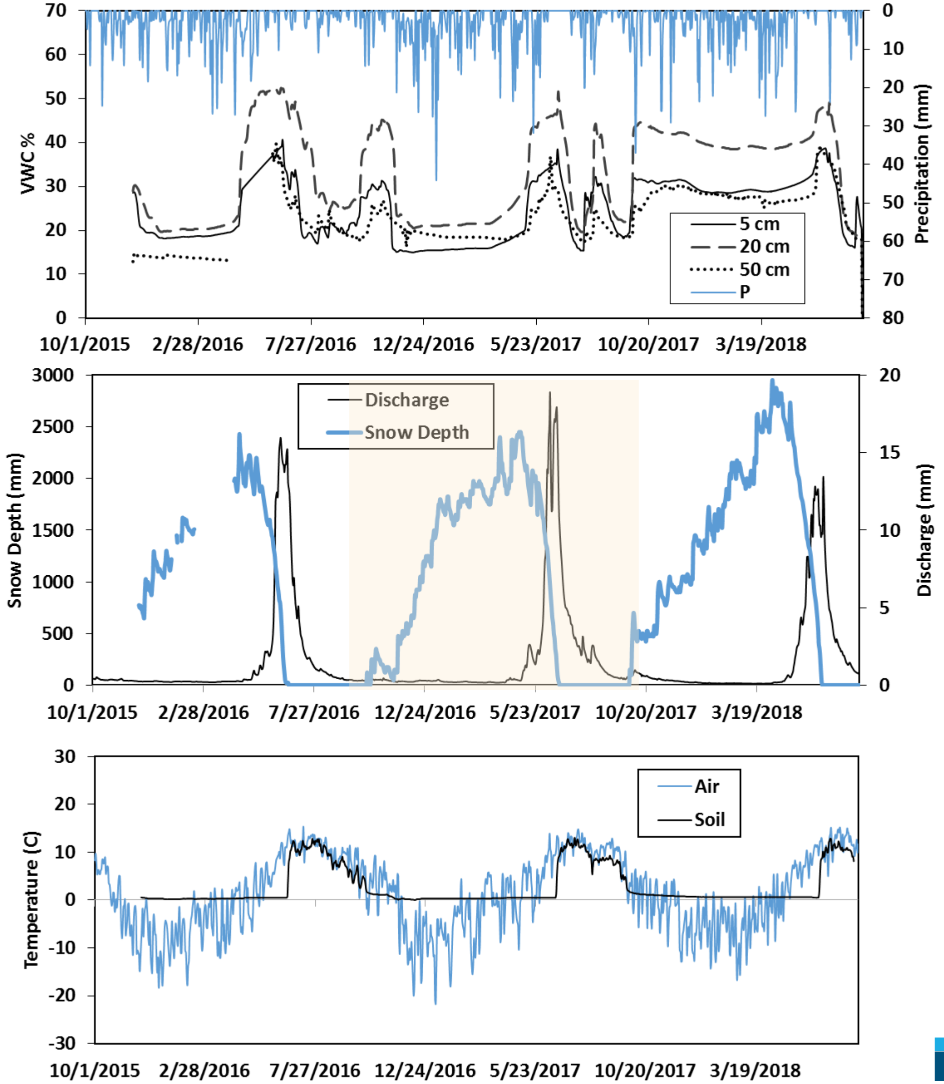


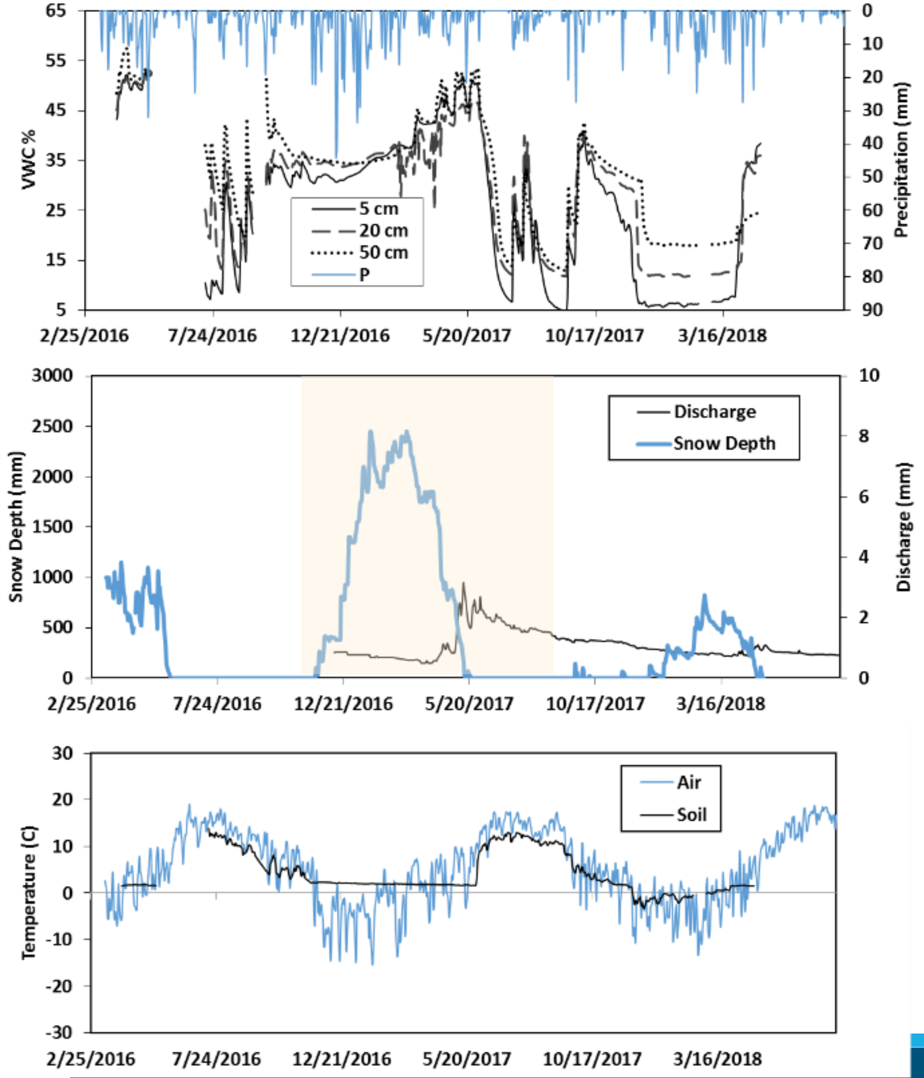


Connection between snowmelt, groundwater & surface water

Michigan Creek
(front range)

Grand Mesa
Persistent





Field monitoring data for the Front Range persistent 1 (Michigan Creek) sites. (a) soil moisture as volumetric water content (VWC) and daily precipitation from PRISM, (b) snow depth and stream stage, (c) air temperature and soil temperature at 5 cm depth.

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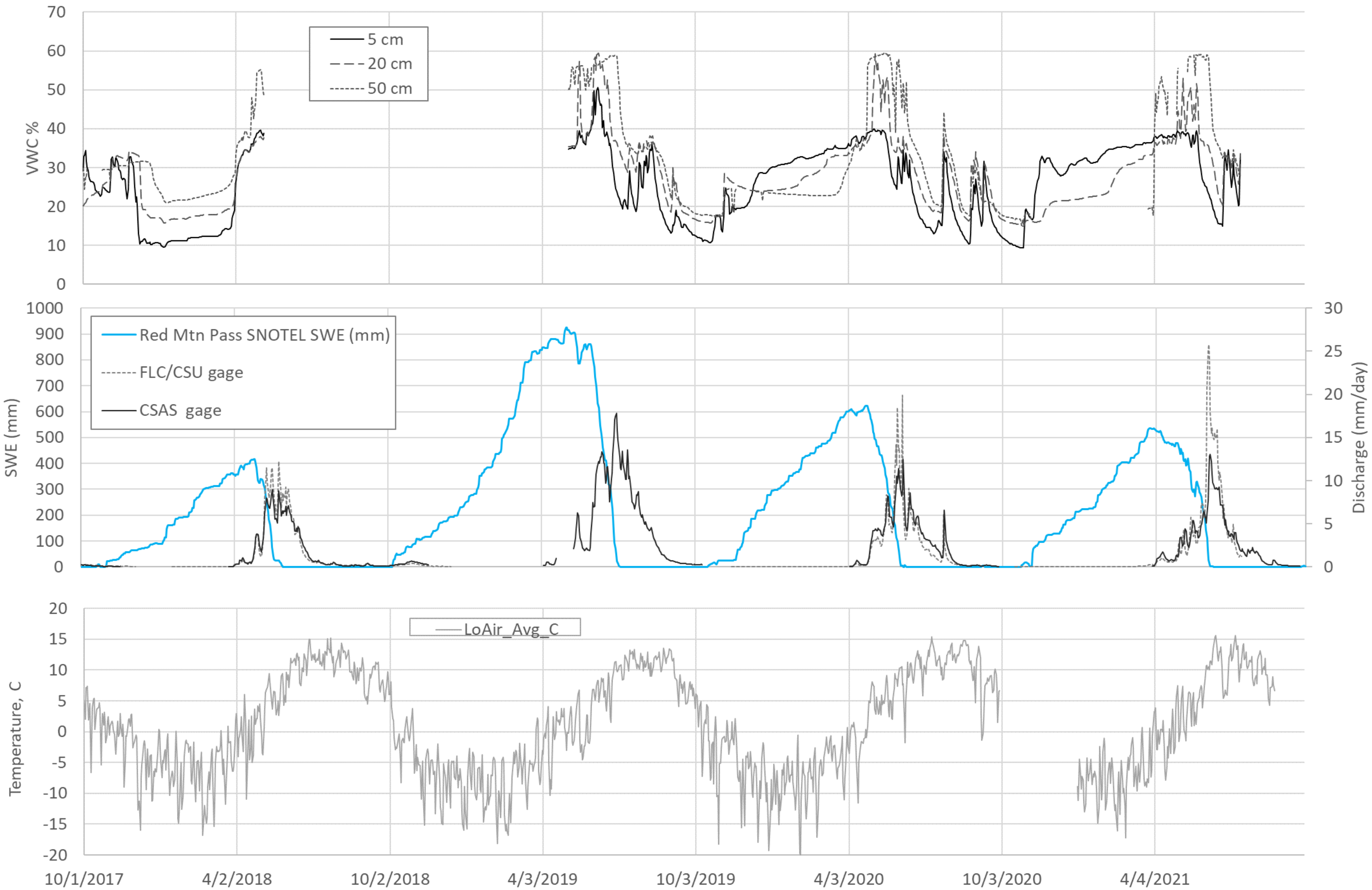
Senator Beck



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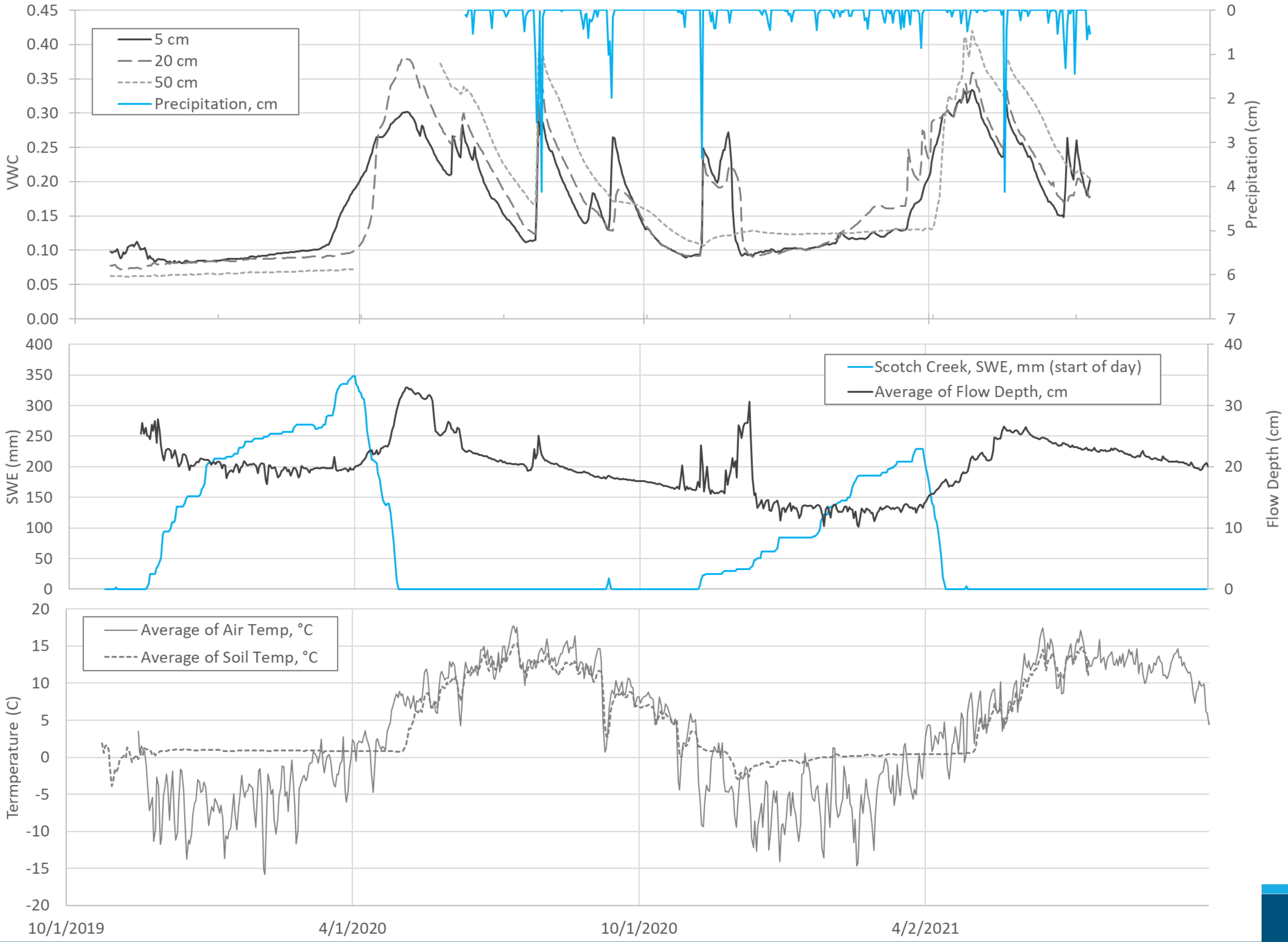
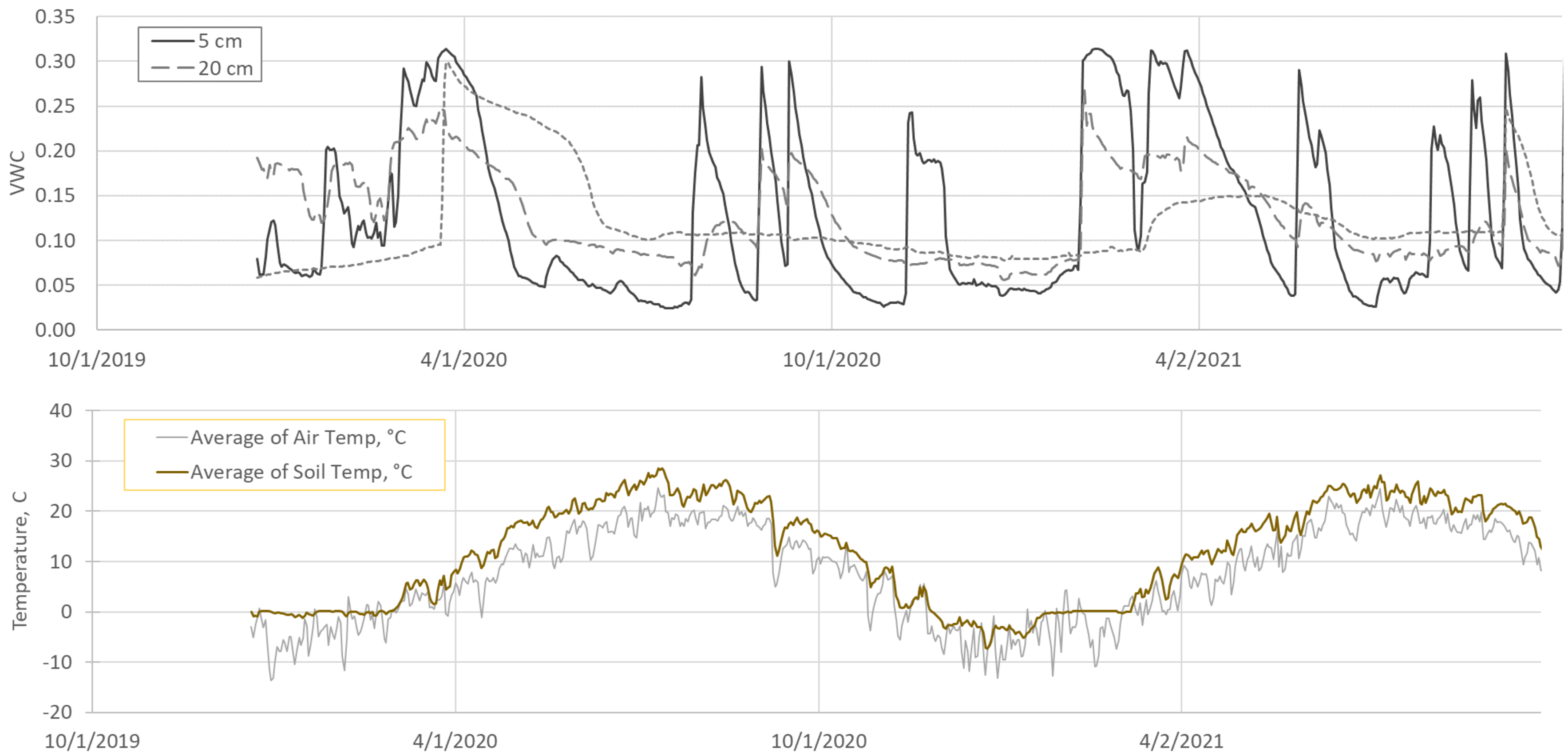
Relay Creek



VWC
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
5 cm
20 cm
50 cm
Precipitation, cm
Precipitation (cm)
0
1
2
3
4
5
6
7
SWE (mm)
400
350
300
250
200
150
100
50
0
Scotch Creek, SWE, mm (start of day)
Average of Flow Depth, cm
Flow Depth (cm)
40
30
20
10
0
Termperature (C)
20
15
10
5
0
-5
-10
-15
-20
Average of Air Temp, °C
Average of Soil Temp, °C
10/1/2019
4/1/2020
10/1/2020
4/2/2021

Basin Creek


5 cm
20 cm
VWC
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
10/1/2019
4/1/2020
10/1/2020
4/2/2021
Average of Air Temp, °C
Average of Soil Temp, °C
Temperature, C
40
30
20
10
0
-10
-20
10/1/2019
4/1/2020
10/1/2020
4/2/2021

Thank you to our partners & supporters

BUREAU OF RECLAMATION

Animas-La Plata Operations, Maintenance and Replacement Association

Russ Howard, ALP OM&R
Susan Behery, BoR
Tami Sheldon, BoR
Shannon Hatch, BoR

CENTER FOR SNOW & AVALANCHE STUDIES

Jeff Derry, CSAS

USDA U.S. FOREST SERVICE
Caring for the land and serving people
United States Department of Agriculture
San Juan National Forest

PURGATORY

Sam Williams, Formerly w/ Purgatory Resort

SNOWMOBILE ADVENTURES
LOCATED AT PURGATORY
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Thank you to our funders…

USDA Climate Hubs
U.S. DEPARTMENT OF AGRICULTURE

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Department of Natural Resources

USGS

DRAMS Project – Dolores River Adaptive Management Support

5-year geomorphic & veg monitoring
Focused on habitat for native fish
Development of public data sharing platform

doloresriver.org

Funding

Partners

Academic Team

- Melissa Clutter, FLC Geosciences
- Cynthia Dott, FLC Biology
- Jon Harvey, FLC Geosciences
- Alan Kasprak, FLC Geosciences
- Gigi Richard, FLC Water Center
- Joel Sholtes, CMU Engineering

Other Team Members

- Rica Fulton, DRBA
- Montana Cohn, RiversEdge West
- Shauna Jensen, USFS
- Shannon Hatch, USBR
- Kevin Hyatt, BLM
- Nate Peters, Conservation Legacy
- Jimbo Buickerood, SJCA

Native Fish Monitoring & Recommendations Team Members

- Celene Hawkins, TNC
- Robert Stump, USBR
- David Graf, CPW
- Ryan Unterreiner, CPW
- Ken Curtis, DWCD
- Bruce Smart, DWCD
- Mike Preston, DWCD

Consultants

- Stacy Beaugh, Strategic by Nature
- Seth Mason & Bill Hoblitzell, Lotic Hydrologic

Overarching Monitoring Goals

Monitoring goals September 2021 through August 2025:

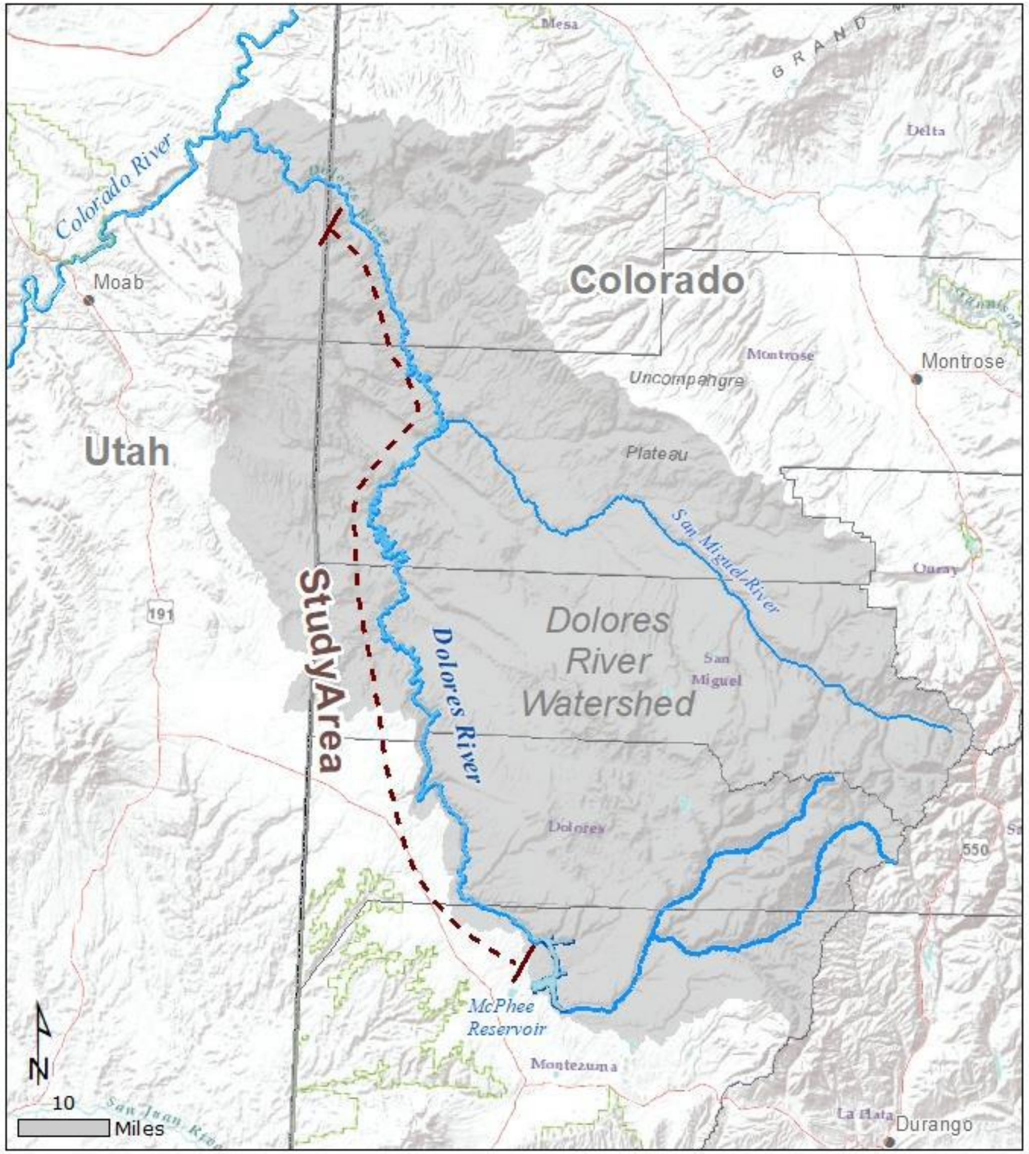
- how the channel and historic and current floodplain and riparian area **respond to altered sediment and water flow regimes** and **assess the trajectory of channel change**
- **influence of riparian vegetation** on channel and floodplain morphology and aquatic habitat
- **inform annual flow management** and release recommendations and the flow hypotheses in the *2014 Implementation Plan.*
- **inform future physical projects** to improve habitat for native fish, improve riparian health, or increase channel complexity.

Focus on channel characteristics **critical to native fish habitat** :

- **clean spawning gravels,**
- **side channels and sloughs,**
- channel **complexity with shallow, refugia zones,** and
- **deep pools** that serve as refugia during low flow years.

Roundtail chub
Flannelmouth sucker
Bluehead sucker
Images from CPW

Monitoring Design – Structure



Baseline & Annual Monitoring

- focus on **characterizing the past and current channel and floodplain** processes and conditions that are critical to native fish habitat.
- includes **historic analyses** of channel and floodplain condition and **annual data collection** to assess current conditions.

Responsive Monitoring

- when **hydrologic conditions warrant a high flow release** from McPhee or **produce natural high flow**
- mobilize to measure channel conditions pre-spill (if needed) and post-spill to determine the extent of channel change.

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Monitoring Design – Structure

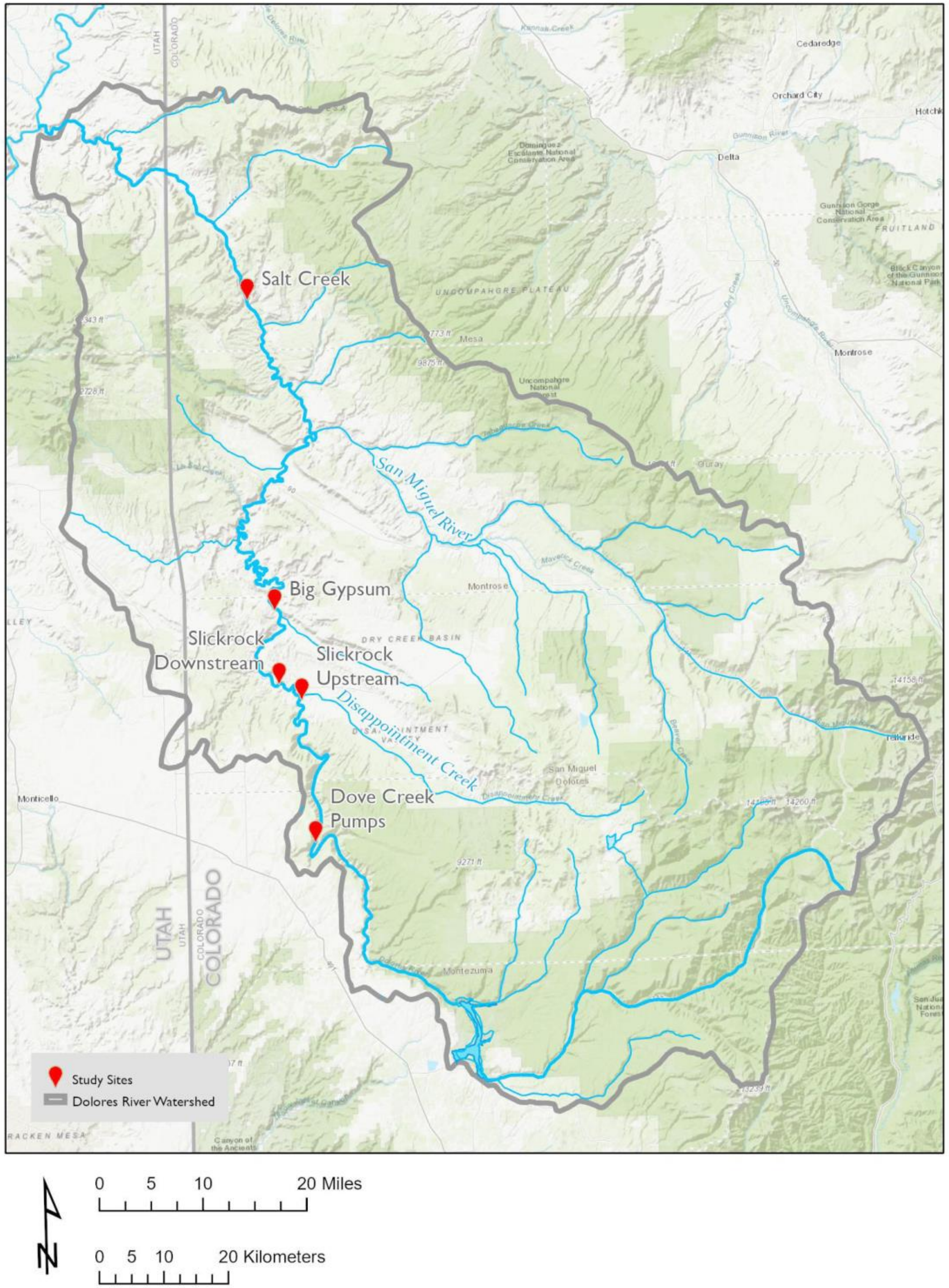
Historic analyses	Baseline monitoring	Annual monitoring	Responsive monitoring
2021/2022	Fall 2021	Summer/Fall 2022 - 2025	Pre/post high flow
Remote/Data analysis	Field/Remote	Field/Remote	Field/Remote

• trajectory of channel complexity from historic aerial imagery
• vegetation encroachment on the channel
• map inundation extents and channel complexity from 2019 release at different discharge levels
• sediment regime
• streamflow regime
	• Elevation models of each site,
	  ◦ UAV flights
	  ◦ Cross-sections, GPS swaths and bathymetry
	• Substrate analyses
	• Longitudinal profiles of select side channels and main channel
	• Establish/re-occupy oblique photo points
	• Discharge measurement at upstream and downstream end of each site for future model calibration
	• Vegetation monitoring.
		• Field survey of 3-4 cross sections per site, including pool bathymetry
		• Elevations of side channel inlets and outlets
		• Substrate analyses
		• Repeat oblique photography
		• Vegetation cover transects and stem density quadrats, including vegetation species/area measurements. Seedling establishment quadrats.
			Pre-spill or anticipated low-elevation snowmelt peak
			• deploy water level sensors
			• paint areas of the substrate to detect movement.
			During high flow:
			• UAV or PlanetLabs imagery to measure stream segment length and identify side channel activity
			• sediment grab samples (monsoon event)
			Post-high flow:
			• Substrate analyses
			• UAV SfM DEM
			• Elev of side channel inlet-outlet
			• Channel complexity
			• Cross section surveys

FLC/CMU	FLC/CMU + Strike Teams	FLC/CMU + Strike Teams	FLC/CMU + Strike Teams

Monitoring Design - Basic Tenets

- Collect data to achieve monitoring objectives
  - Prioritize data collection based on cost & effort vs. what we'll learn from the data
- Utilize remote sensing when possible to minimize field data collection
- Streamline and automate field data collection as much as possible
  - ◦ Accessible for students and strike teams



Monitoring Design – Spatial Scales

Field study sites – (<400 meters) field data collection including detailed bathymetry for future modeling, vegetation transects, pool surveys, and cross-sections.

Study reaches – (~500-1000 meters) stretches of river surrounding each field study site including the immediate upstream and downstream context.

Study segments - longer section of river, ~10-20 km that reflect the characteristics of a particular segment of the river.

Monitoring Design – Study Sites

Monitoring Design – Study Sites

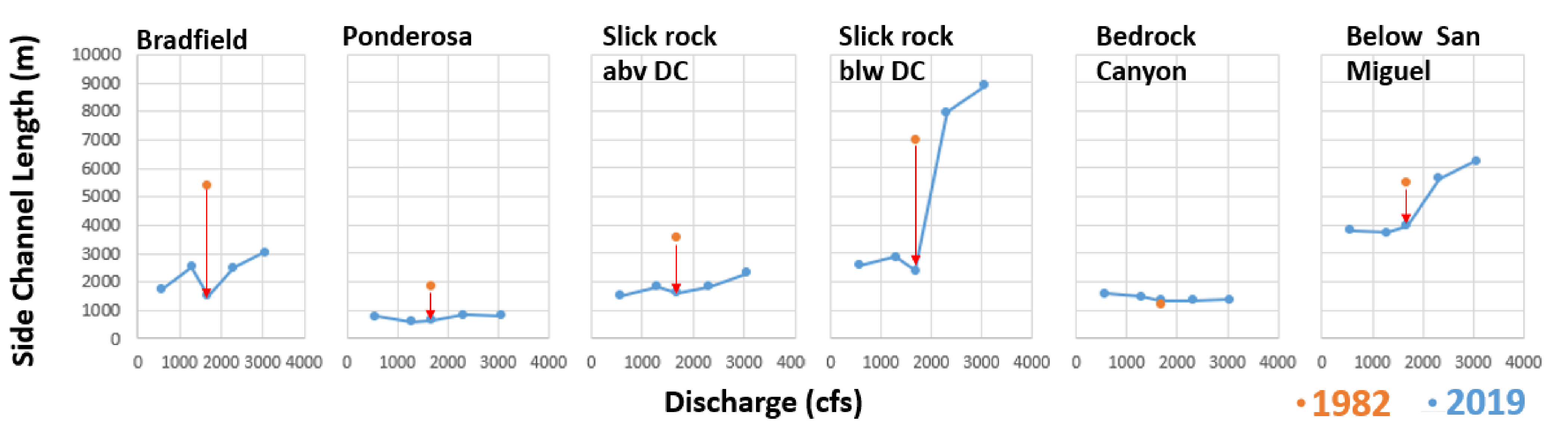
Historic Analysis – Preliminary Results

Data & analyses from Dr. Jon Harvey and Dr. Alan Kasprak, FLC

2022: Analyzed 2019 release using Planet satellite imagery (Jon Harvey with FLC students Charlie Brockway, Braden Cazier, and Jack Tingwall)

- *New imagery source that captures daily images of whole planet at 3m resolution*
- *How well were side channels inundated throughout that release? Studied 6 discharges from ~300 cfs to ~3300 cfs.*
- *How does that compare to what we see in pre-dam imagery (from 1982, at ~1600 cfs)?*

Side-channel complexity on the lower Dolores



- Tight canyon segments (Ponderosa & Bedrock) show ~no change in side-channel availability as discharge ramps up
- Wider valley segments below disappointment creek show **dramatic increase in complexity above ~2000 cfs**
  - *sweet spot for creating refugia?*
- Compared with pre-dam conditions, **moderate floods (~1600 cfs) are inundating fewer side channels** in 5 out of 6 segments (red arrows)

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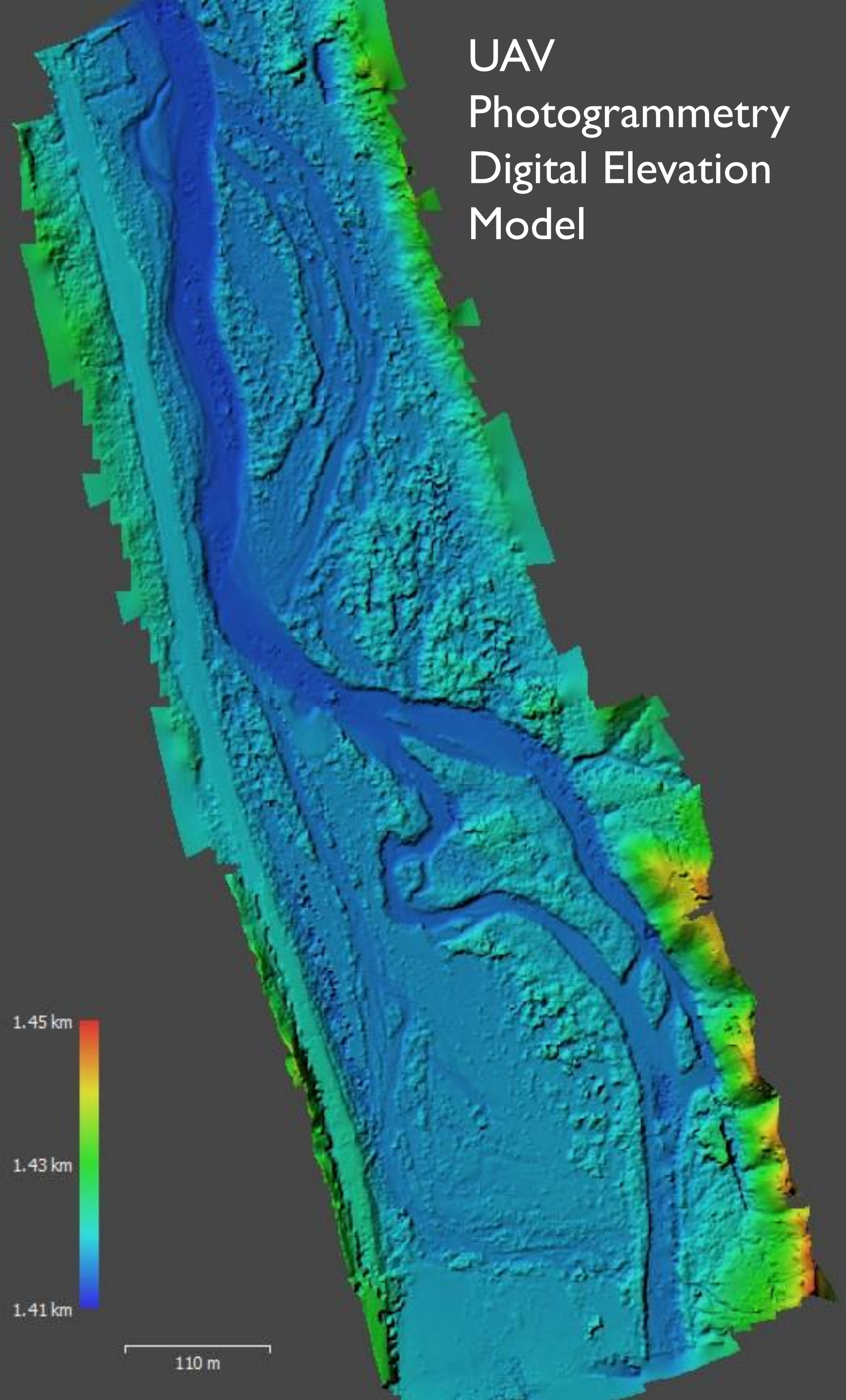
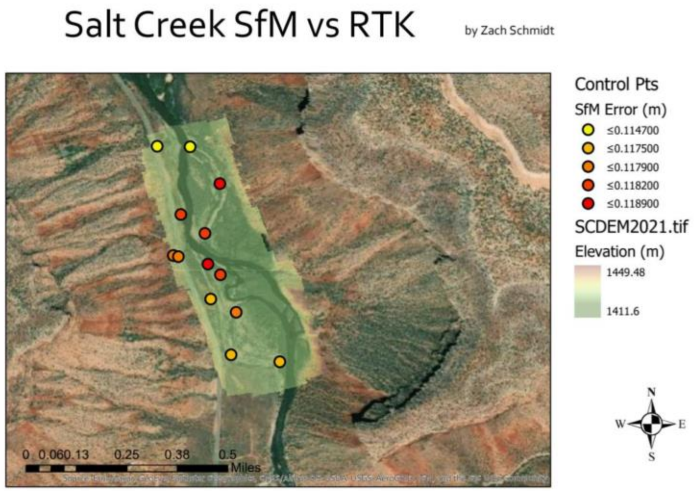


UAV Photogrammetry Digital Elevation Model

Salt Creek Site 2021 Monitoring

Photos, map and data from Dr. Joel Sholtes, CU-Boulder/CMU



Comparison of RTK-GPS elevations and SfM digital elevation model elevations.

Gypsum Valley 2021 Monitoring

Photos, map and data from Dr. Joel Sholtes, CU-Boulder/CMU

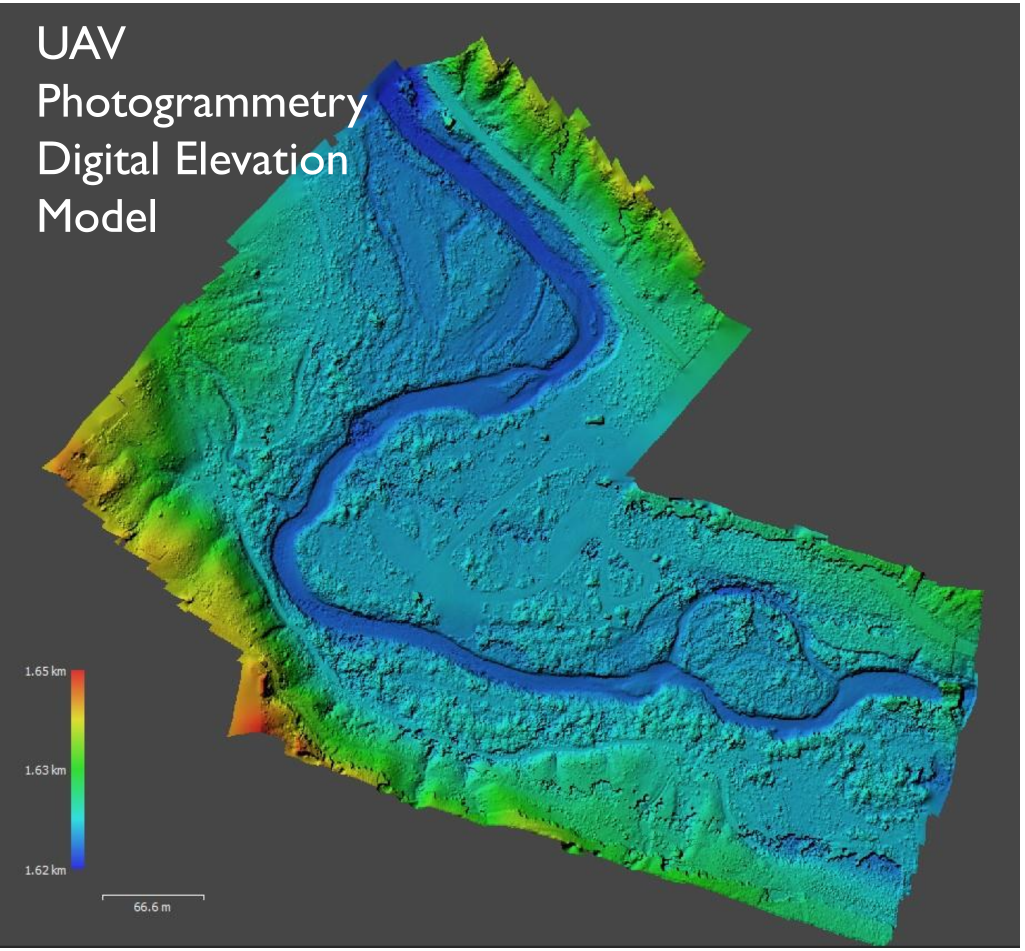


Figure 11. Overview of profiles (colors match the profile graphs)

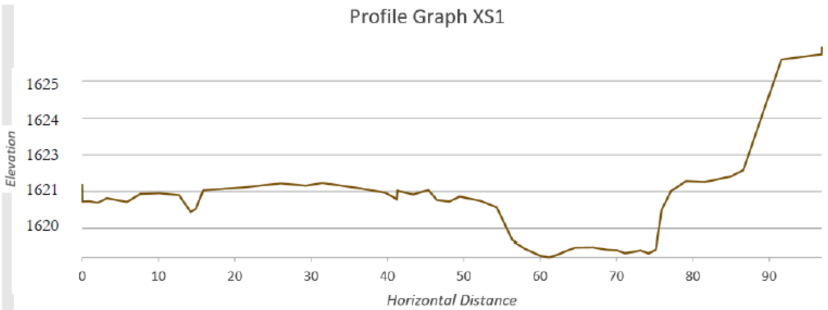


Figure 8. Profile of cross section 1 at Big Gypsum (values in meters)

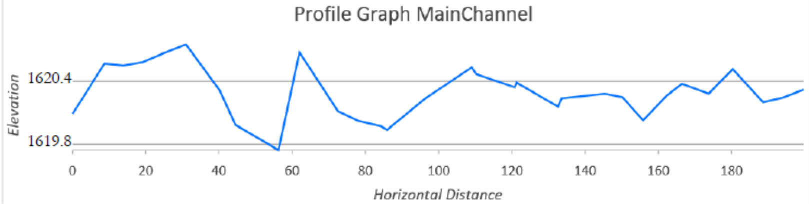


Figure 9. Profile of main channel at Big Gypsum (values in meters)

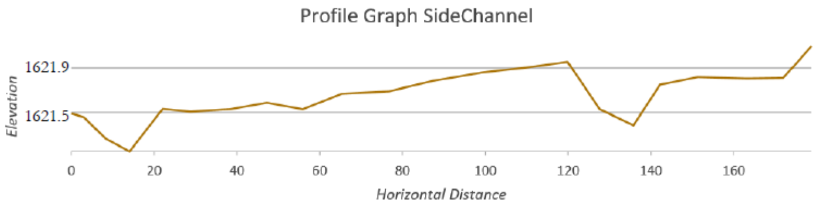


Figure 10. Profile of side channel at Big Gypsum (values in meters)

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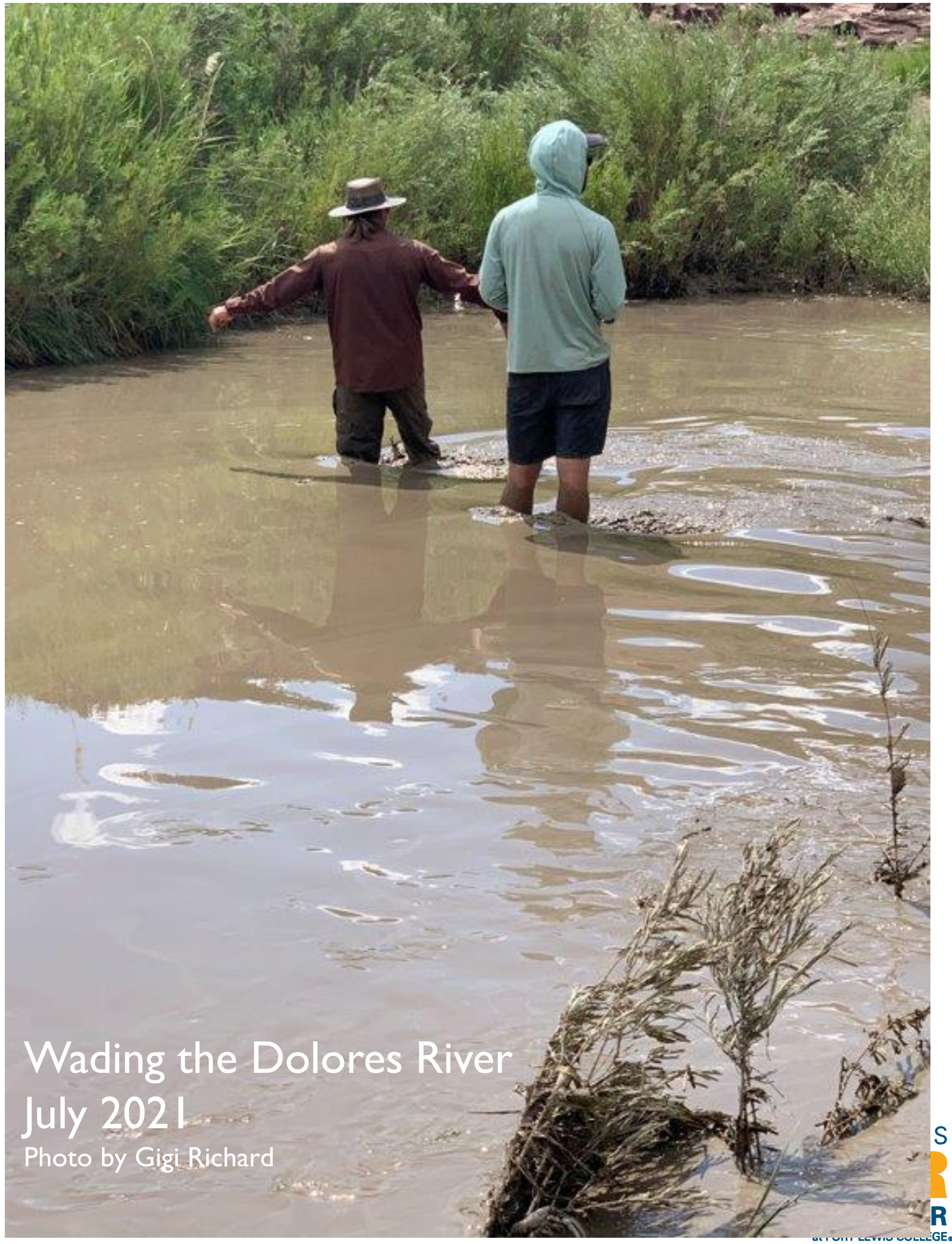
at FORT LEWIS COLLEGE

2021 Monsoonal Flows

Disappointment Creek ~200 cfs
July 2021
Photo by Gigi Richard



Wading the Dolores River
July 2021
Photo by Gigi Richard

2021 Monsoonal Flows

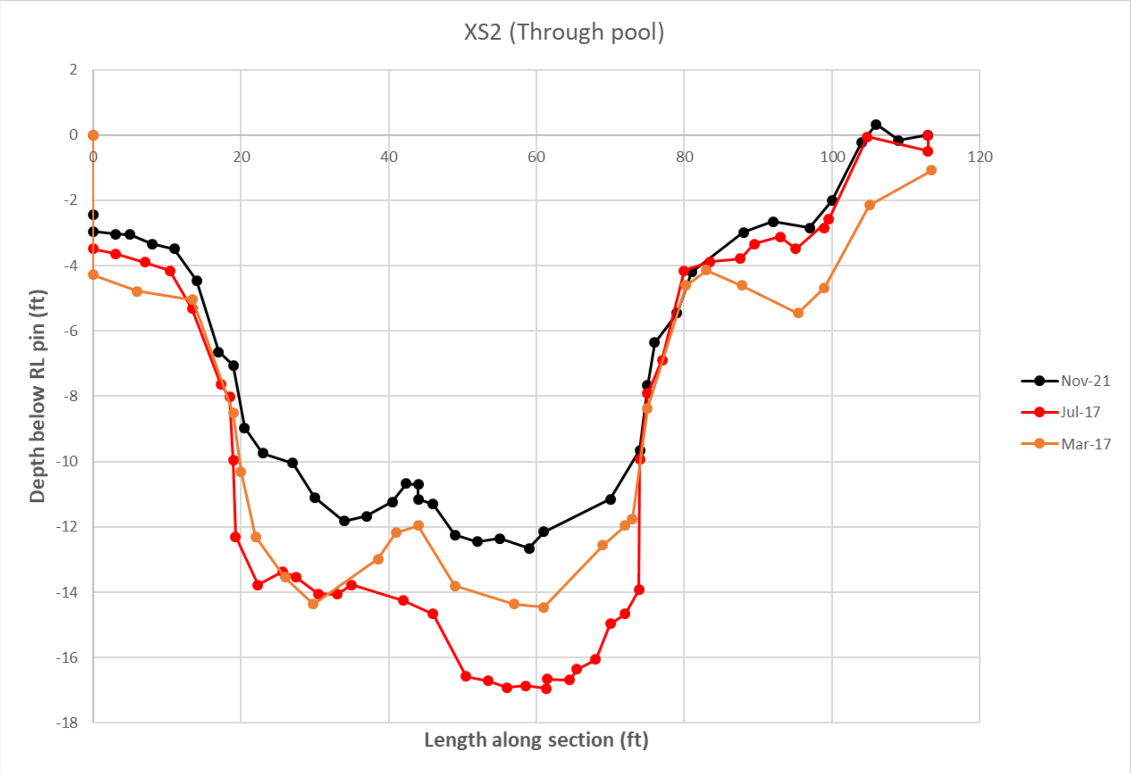
Slick Rock Sites
November 7-8, 2021
Post-monsoonal floods
Photos by Jon Harvey

Fieldwork – Preliminary Results

Data & analyses from Dr. Jon Harvey, FLC

Fall 2021: Surveyed sites at Slick Rock upstream and downstream of Disappointment Creek

- Still processing, but initial results show:
  - Cross sections at slick rock upstream show minimal changes w.r.t. 2017 surveys
  - Cross section at slick rock downstream (through a pool) show that it was filling with mud prior to 2017, got scoured out during the 2017 release, and has since filled in again. Clear connection to Disappointment Creek mud based on observations during 2021 monsoon season.



Left: some screenshots from the 3-D point cloud collected during fall 2021 field season, showing the de-watered version of the slick rock downstream site. Note that mud can be distinguished from cobbles in this dataset.

MetaCat Database

waterdata.fortlewis.edu

- a repository for data and metadata (documentation about data)
- flexible & open-source catalog
- used extensively throughout the world to manage environmental data
- documented in a standardized way, so the data are well and consistently described
- can be easily searched, compared, merged, or used in other ways
- helps find, understand and effectively use data sets they manage or that have been created by others.

National Center for Ecological Analysis and Synthesis at UC Santa Barbara

Thank you!

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