

Union Creek Stream Stabilization Project Final Report



Submitted to: Colorado Water Conservation Board

Submitted by: Colorado Mountain College Natural Resource Management Program

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Table of Contents

List of Figures 2

BACKGROUND 3

PROJECT OBJECTIVES 3

 Benthic Macroinvertebrate (BMI) 5

 Fish Population Statistics 5

 Stream Discharge 6

 General Site Observations..... 7

 Bed Material..... 10

 Vegetation Monitoring..... 11

 Channel Surveying..... 12

EDUCATION AND OUTREACH 14

 Education 14

 Outreach..... 15

Project Design 16

Implementation..... 18

List of Figures

Figure 1. Site Map	4
Figure 2. Fish Shocking - September 2011.	5
Figure 3. Results from JakeO'Matic for fish data collected at Union Creek above and below river restoration project.	6
Figure 4. Hydrograph of Union Creek discharge April-September, 2011	7
Figure 5. Pre-construction photo of Meander 1.	8
Figure 6. Post-construction of Meander 1.	8
Figure 7. Pre-construction photo of Meander 2.	9
Figure 8. Post-construction photo of Meander 2.....	9
Figure 9. Wolmann Pebble Count results.....	11
Figure 10. Soil lift willows after 8 weeks of growth.	11
Figure 11. Same willows after 11 weeks of growth.	11
Figure 12. Same willows after 21 weeks of growth.	11
Figure 13. Survey points collected by CPW.....	12
Figure 14. Transects of Union Creek.	13
Figure 15. Willow Harvesting with LCMS 8th Grade Students, 2011.	14
Figure 16. Sorting invertebrates with Colorado UpLift students after collection.	15
Figure 17. Final Union Creek Plan and Map.	17
Figure 18. Staking pine bough fascines to the back of the bank.....	18
Figure 19. Rolling out Coir fabric on top of fascine.....	19
Figure 20. Folding Coir fabric over soil.....	19
Figure 21. Completed soil lift.	20
Figure 22. Soil lift with erosion mats.....	20
Figure 23. Completed channel realignment at Meander 2.	21

BACKGROUND

Union Creek is a small tributary of the Arkansas River in Lake County, Colorado serving as spawning and nursery habitat for a stretch of the Arkansas River whose brown trout population is recovering from historic mining activities. Erosion at several meander banks along Union Creek had the potential to release a large amount of fine-grained sediment into the creek, which would impair the trout spawning habitat. Therefore, preservation of this critical habitat was important for reaching restoration goals in the Upper Arkansas River. Migration of Union Creek, within the study reach, also threatened the Old Leadville Stage Road, which is of historical significance and serves as a site access road for EPA's remediation efforts, Excel Energy, and Arkansas Headwaters Recreation Area personnel.

Union Creek is a perennial stream largely controlled by snow melt run-off. Average discharge during low flow conditions is 4.5 cfs, while high flow discharge can increase to above 20 cfs (CWCB, 1991). A diversion of Union Creek runs through Mount Massive Lakes, Inc. and is utilized for 22 trout fishery lakes. A portion of the water diverted by Mount Massive Lakes is redirected into Union Creek prior to passing under the Old Leadville Stage Road and entering the floodplain of the Arkansas River. Union Creek then meanders less than 1.5 miles before entering the Arkansas River (Figure 1). The entire project area is located on Colorado Parks and Wildlife (CPW) property in the Arkansas Headwaters Recreation Area and is open to the public.

Limited discharge data were collected in 1990-1991, upstream of the project site, primarily for determination of withdraws to Mt. Massive Lakes. One fish shocking event was also performed upstream of the project site. While this data helped to define some preliminary project metrics, the data was insufficient and baseline data was collected as part of the project. No other restoration projects have occurred within the Union Creek Watershed, however, reclamation and restoration of the Arkansas River and its impacted fluvial deposits are underway in close proximity to Union Creek.

PROJECT OBJECTIVES

- To stabilize and restore two severely degraded meander banks on Union Creek
- To protect and stabilize the Old Leadville Stage Road
- To analyze the effectiveness of bioengineering river restoration techniques
- To provide ecological, morphological, and bioengineering educational opportunities to local landowners, stakeholders, and students
- To create partner and mentoring opportunities between landowners, stakeholders, and students



Figure 1. Site Map

The main goal of this project was primarily infrastructure protection. Secondary, goals included maintaining or improving riparian habitat and vegetation along the repaired reaches.

Baseline data was necessary to assess the optimal bioengineering methods for this site, in addition to establishing baseline conditions to assist with pre- and post-project evaluation. Data collection consisted of benthic macroinvertebrate and fish population statistics, stream discharge measurements, general site observations, pebble counts, vegetation monitoring, and channel surveying.

Benthic Macroinvertebrate (BMI)

BMI data was collected to assess aquatic conditions based on biological communities by CPW personnel from locations above and below the project site on Union Creek in June 2011. Sampling entailed the collection of five replicate samples in both locations and BMI was collected with a 0.1m² Hess sampler and preserved in the field with 70% ethanol (Clements et al., 2000).

Although some differences were observed between sites, both sampling locations produced results that were typical of a high-elevation Colorado stream. Benthic macroinvertebrate communities were adequately diverse at both locations and both sites produced several taxa that are known to be sensitive to disturbances. The benthic community at the upper site exhibited slightly better community balance, while the lower site maintained higher densities and slightly better taxa richness (including a slightly higher number of sensitive taxa). In general, both sites appeared to support relatively healthy aquatic communities during 2011. (See Appendix A for detailed BMI data).

Fish Population Statistics

Data recorded during fish sampling include number, length, and weight of fish by species. The electrofishing method used was the *Seber-LeCren Two Pass Removal* (depletion) method (Bagenal, 1978; Seber, 1982; Seber and LeCren, 1967) which entails shocking fish along a reach of stream and quickly collecting the shocked fish for subsequent cataloging. Almost immediately, a second pass of shocking is accomplished. Fish length and weight data are collected during each pass.

Fish data were collected on September 9, 2011 by USFWS and Trout Unlimited personnel (Figure 2). Fish were collected and noted for species, weight and length. These data were run through Jake O'Matic for population. Please see results in Figure 3.



Figure 2. Fish Shocking - September 2011.

Water **Union Creek** Date **09/09/2011**

Location **Site 1 @ upstream of proposed construction area &**

Drainage **Arkansas River** Water Code **40903**

Crew **L. Archuleta, B. Sanchez, M. Cole**

Notes

UTM Zone

UTM X **0**

UTM Y **0**

Station Length (ft) **272**

Station Width (ft) **10.0**

LEVEL 2 - STREAM SURVEY (2 PASS REMOVAL)

SAVE PRINT DONE

SUMMARY INFORMATION

Species	# Caught	% Catch	Min Size	Capture P	#/Mile	95% CI	#/Acre	95% CI	Lbs/Acre	95% CI
BRK	1	2	151	1.00	19	0	16	0	3	0
LGS	6	10	150	0.83	116	29	96	24	23	6
LOC	50	86	119	0.94	973	20	803	16	214	4
MAC	1	2	150	1.00	19	0	16	0	8	0

LENGTH FREQUENCY RECORD (cm)

Species	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	38-40	40-42	42-44	44-46	46-48	48-50	50-52	52-54	54-56	56-58	58-60	>60
BRK							1			1																					
LGS								1	2		1		2																		
LOC	12		2	12	6		1	5	11	3	3	9	8	8	1	1															
MAC																		1													

Water **Union Creek** Date **09/09/2011**

Location **Site 2 @ downstream of proposed construction area**

Drainage **Arkansas River** Water Code **40903**

Crew **L. Archuleta, B. Sanchez, M. Cole**

Notes

UTM Zone

UTM X **0**

UTM Y **0**

Station Length (ft) **359**

Station Width (ft) **9.9**

LEVEL 2 - STREAM SURVEY (2 PASS REMOVAL)

SAVE PRINT DONE

SUMMARY INFORMATION

Species	# Caught	% Catch	Min Size	Capture P	#/Mile	95% CI	#/Acre	95% CI	Lbs/Acre	95% CI
LOC	51	100	119	0.70	822	132	685	110	167	27

LENGTH FREQUENCY RECORD (cm)

Species	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	38-40	40-42	42-44	44-46	46-48	48-50	50-52	52-54	54-56	56-58	58-60	>60
LOC			1	20	6		2	8	12	1	9	6	5	2	3	2	1														

Figure 3. Results from JakeO'Matic for fish data collected at Union Creek above and below river restoration project.

Stream Discharge

Discharge was measured using the velocity-area method with a Marsh-McBirney Velocity Meter at a permanent monitoring site at the end of the project reach. Discharge was collected monthly below the project site throughout 2011. The hydrograph for 2011 can be found in Figure 4.

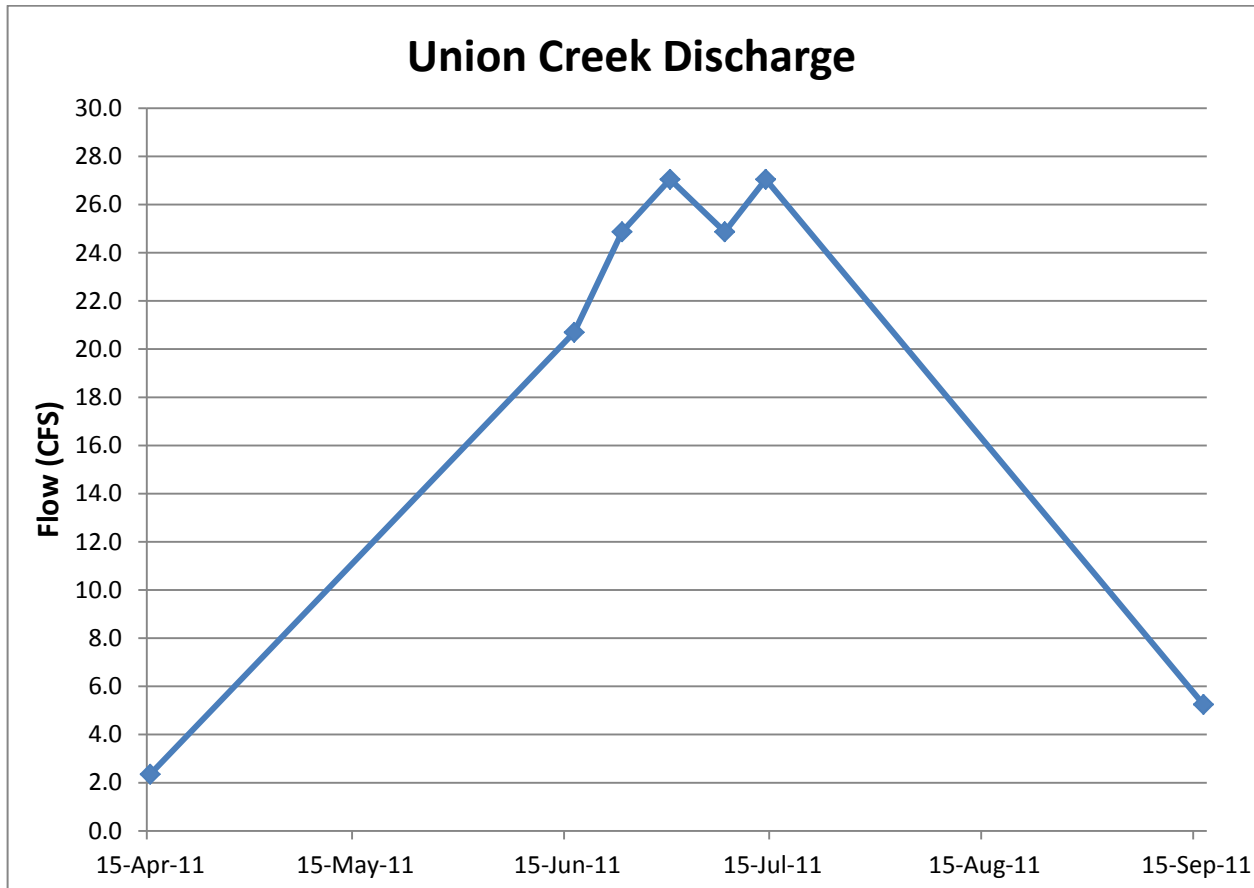


Figure 4. Hydrograph of Union Creek discharge April-September, 2011

General Site Observations

General site observations were noted during each site visit by NRM staff. A project field notebook was used to record all applicable observations and measurements and is included in Appendix A.

Photo monitoring locations provided a consistent source of recording site observations and changes overtime. Photo monitoring occurred throughout the site and the locations captured the immediate project areas as well as Union Creek above and below the project site. (Figures 5, 6, 7, 8). Complete photo documentation can be found in Appendix B.



Figure 5. Pre-construction photo of Meader 1.



Figure 6. Post-construction of Meander 1.

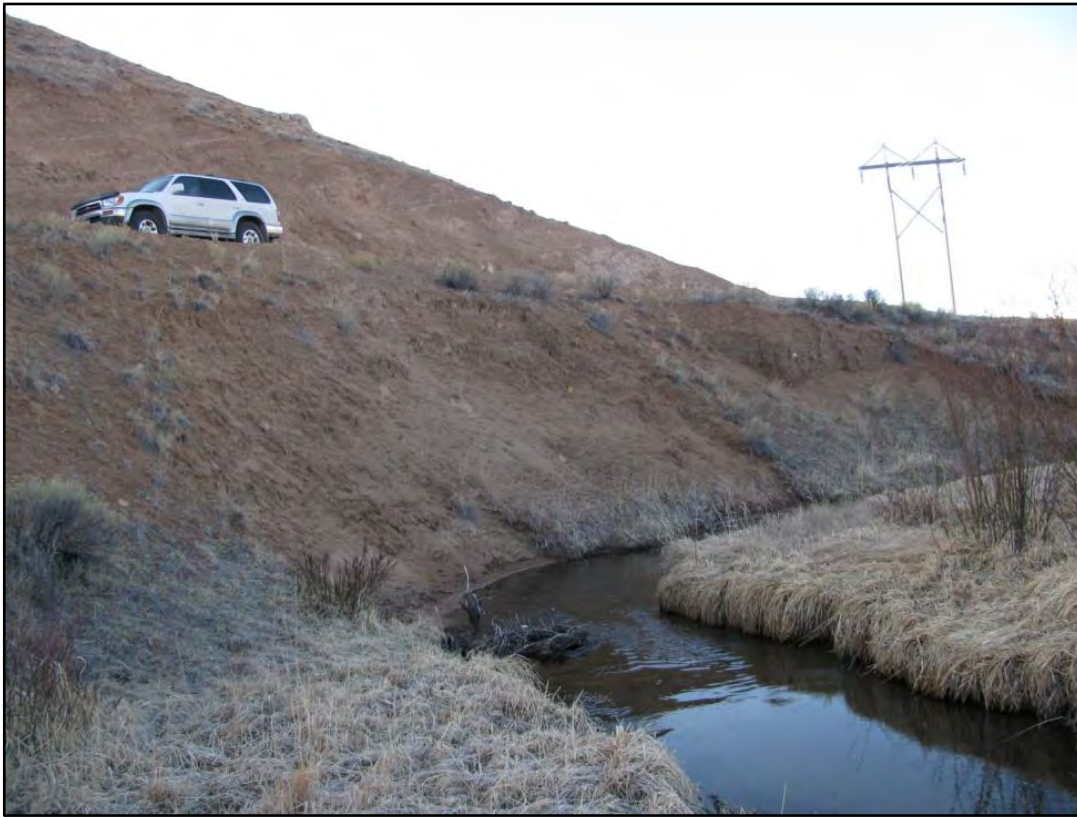


Figure 7. Pre-construction photo of Meander 2.



Figure 8. Post-construction photo of Meander 2.

Bed Material

A pebble count (Wolman, 1954) was completed above and below the project reach on April 14, 2011. Data is contained in Figure 9 below.

Project:	Union Creek	Date:	14-Apr-11
Location:	Lake County, CO	Sample Type:	
Names:	L. Vecchio/ NRE-227	Purpose of Sample:	River Restoration Project
		Water depth range:	<2 feet
Sample Location in Reach:	Between Meander 1 & 2	Recent Weather:	Light Snow
Armor:		Current Weather:	Clear, windy, cold
Bedrock:		Largest Particle:	
Debris Present:		CEM:	
Other information:			

Particle	Type	< Size (mm)	count	% fraction	count cumulative	% cumulative	Note
silt/clay		0.062					
very fine	sand	0.125					
fine	sand	0.250		0.0%	0	0.0%	estimate <% if pebble count
medium	sand	0.500		0.0%	0	0.0%	estimate <% if pebble count
coarse	sand	1.000		0.0%	0	0.0%	estimate <% if pebble count
very coarse	sand	2.000		0.0%	0	0.0%	estimate <% if pebble count
very fine	gravel	4.000		0.0%	0	0.0%	estimate <% if pebble count
fine	gravel	6.000	1	1.0%	1	1.0%	estimate <% if pebble count
fine	gravel	8.000	1	1.0%	2	2.0%	estimate <% if pebble count
medium	gravel	12.000	3	3.0%	5	5.0%	
medium	gravel	16.000	4	4.0%	9	9.0%	
coarse	gravel	24.000	13	13.0%	22	22.0%	
coarse	gravel	32.000	20	20.0%	42	42.0%	
very coarse	gravel	48.000	14	14.0%	56	56.0%	
very coarse	gravel	64.000	9	9.0%	65	65.0%	
small	cobble	96.000	9	9.0%	74	74.0%	
small	cobble	128.000	8	8.0%	82	82.0%	
large	cobble	192.000	5	5.0%	87	87.0%	
large	cobble	256.000	7	7.0%	94	94.0%	
small	boulder	384.000	3	3.0%	97	97.0%	
small	boulder	512.000	2	2.0%	99	99.0%	
medium	boulder	1024.000	1	1.0%	100	100.0%	
large	boulder	2048.000					
very large	boulder	4096.000					

* bold indicate standard scale ASCE No. 54

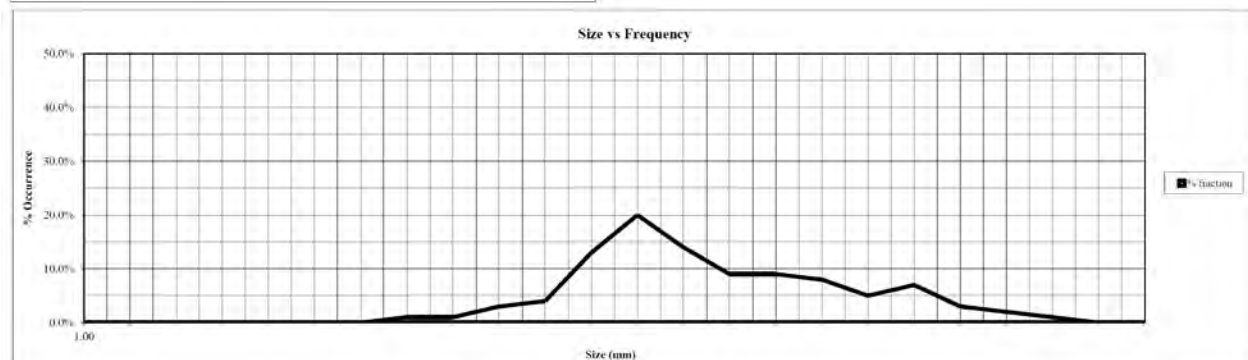
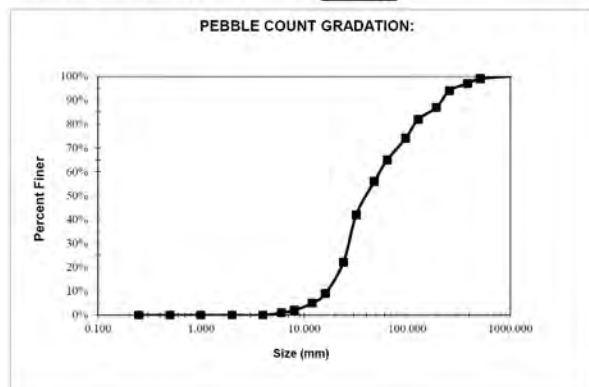


Figure 9. Wolmann Pebble Count results.

Vegetation Monitoring

Vegetation monitoring occurred after the soil lift construction in April and May 2013. The photos below (Figure 10, 11, 12) document the survival rate of willow transplants. CMC NRM will conduct additional vegetation monitoring as CMC NRM courses are available to perform the work in the summer and fall of 2014.



Figure 10. Soil lift willows after 8 weeks of growth.



Figure 11. Same willows after 11 weeks.



Figure 12. Same willows after 21 weeks.

Channel Surveying

Channel surveying occurred by CPW, USBLM, and CMC personnel to gain baseline morphological data. This data is displayed in map form in Figures 13 and 14 below.

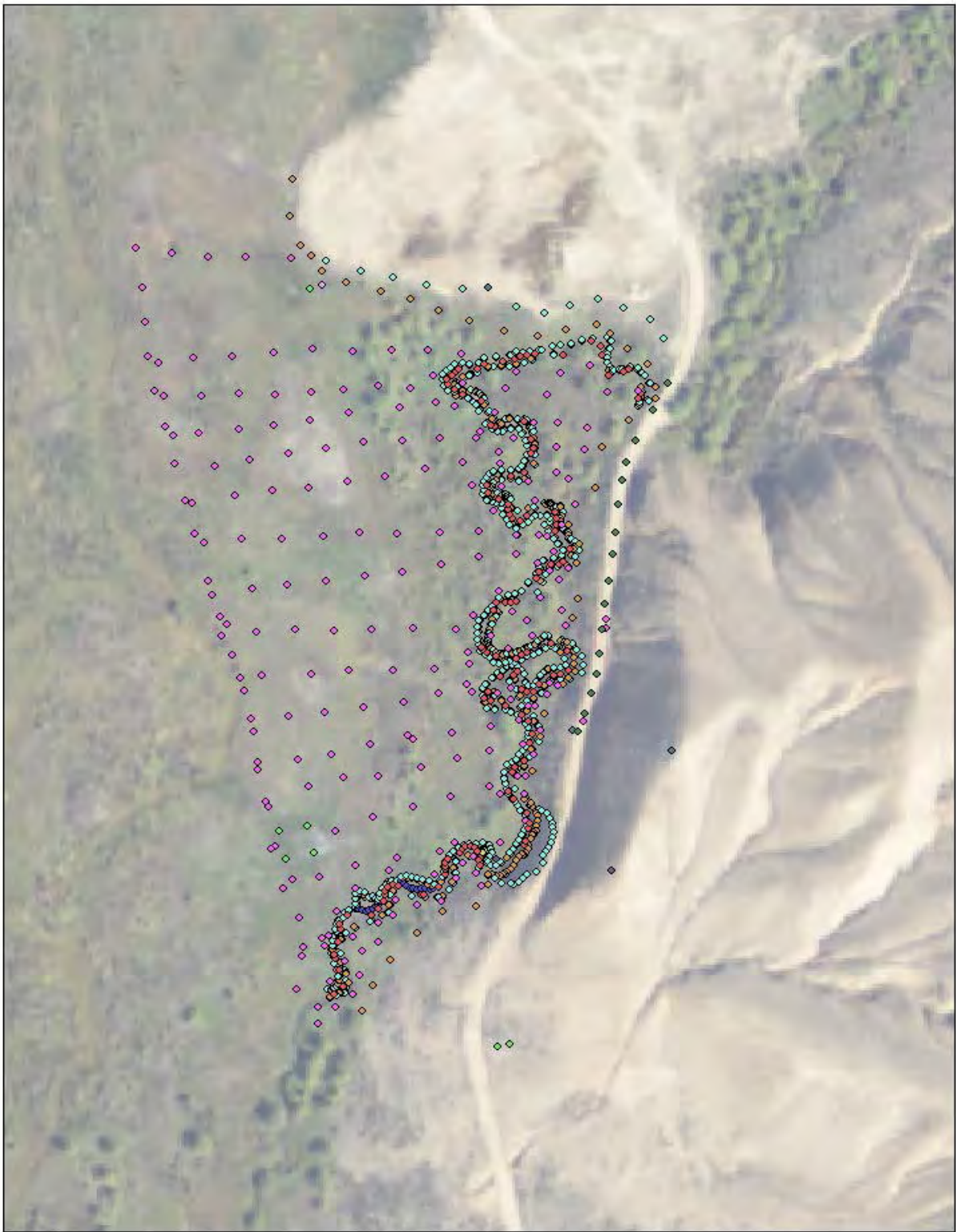


Figure 13. Survey points collected by CPW.

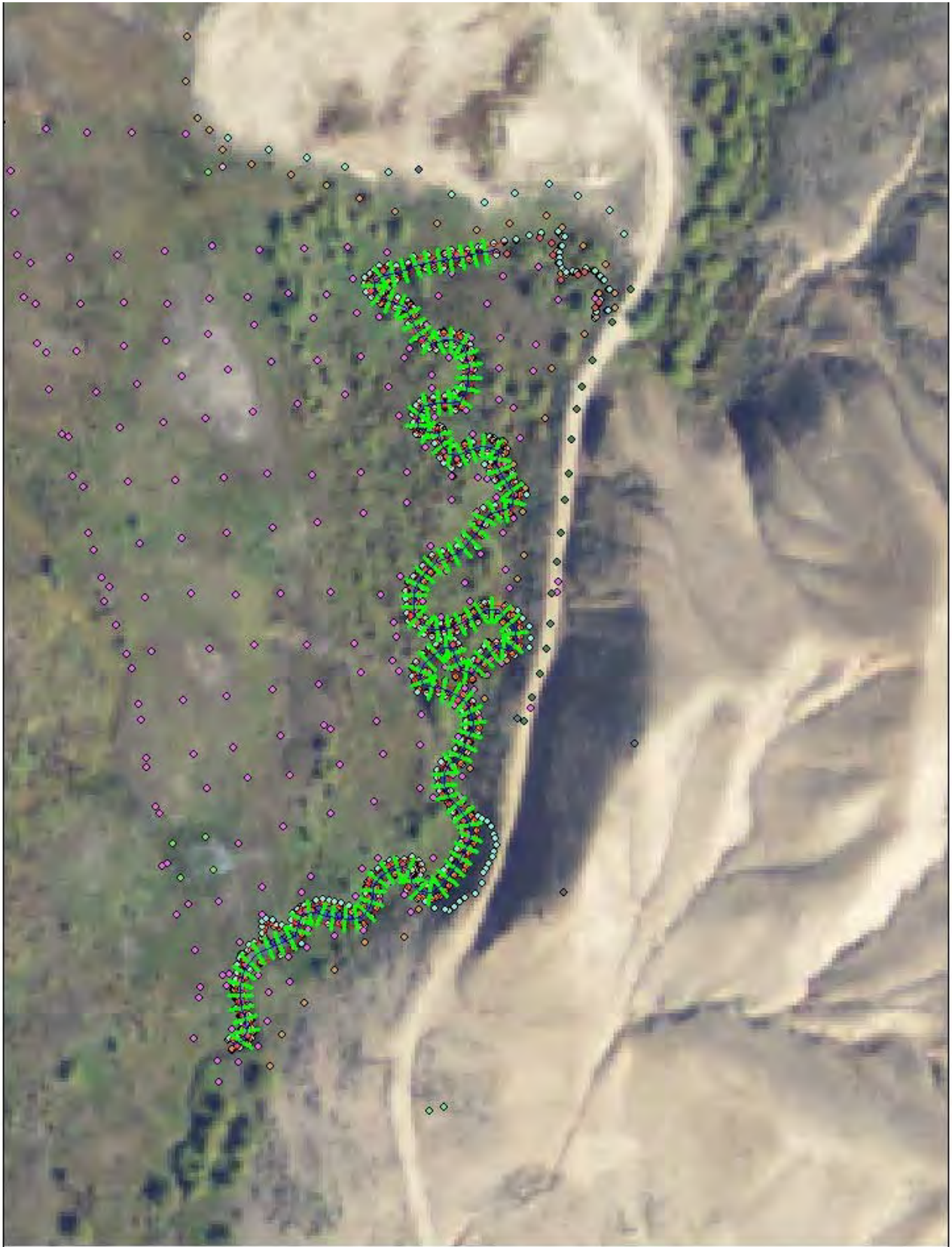


Figure 14. Transects of Union Creek.

EDUCATION AND OUTREACH

Education

The NRM Program is dedicated to providing science, technology, engineering, and math (STEM) education to K-12th grade students through partnerships with schools, youth organizations and working professionals. The Union Creek project integrated outdoor learning into environmental curriculum helping to instill a connection to the local environment and a desire for active stewardship. This is the focus of the NRM program's ongoing partnership with the Lake County School District, Keystone Science School, and Denver middle and high school students through Colorado UpLift. These partnerships allow students to gain hands-on data collection experience in the disciplines of geomorphology, hydrology, ecology, and biology.

In partnership with Keystone Science School, CMC NRM assisted with the *Education in Action: Mining and Water Quality* program at the Lake County Middle school working directly with the 8th grade science class. *Education in Action: Mining and Water Quality* is a semester long problem-based initiative with a mission to foster a sense of community, inspire critical thinking, and teach the process of citizen action. In April 2011, 75 Lake County Middle School 8th grade students participated in the *Education in Action: Mining and Water Quality* Program service learning project at the Union Creek site. Students were given instruction on how to harvest willows and then assisted in the actual harvesting of the willows at the Union Creek site (Figure 15).



Figure 15. Willow Harvesting with LCMS 8th Grade Students, 2011.

Colorado UpLift is a non-profit organization that focuses on building long-term, life-changing relationships with urban youth and is involved in student's lives through in-school classes, teaching leadership and life-skills; after school programs; and adventure activities, which are primarily based in the summer; and post-secondary training. The experiences that CMC provides are unique

opportunities for students to have exposure to STEM education in a new and exciting atmosphere. On June 30, 2011, Colorado UpLift middle school students sampled and sorted macroinvertebrates at Union Creek (Figure 16).



Figure 16. Sorting invertebrates with Colorado UpLift students after collection.

Several CMC classes participated in the Union Creek project. In 2011, the Reclamation Site Monitoring course (NRE-227) collected water quality, discharge, pebble count, and habitat mapping data. The Field Monitoring course (NRE-127) also participated in data collection of discharge and water quality. During the spring semester of 2013, the Introduction to Hydrology (NRW-121) and Advanced Hydrology (NRE-221) classes assisted with the soil lift project.

Landowners, community members, and environmental professionals participated in bioengineering and surveying workshops at Union Creek in October 2011. The bioengineering workshop was conducted by Jo Christensen, USBLM Montana, who is an expert in bioengineering techniques. CPW personnel conducted the surveying workshop. Over this two day period, the USFS, Lake County Commissioners, Lake County Open Space Initiative, Arkansas Headwaters Recreation Area, EcoMetrics, LLC, Colorado Division of Wildlife (now Colorado Parks and Wildlife) and Lake County citizens participated in the educational workshops.

Outreach

The Union Creek project has been presented to numerous organizations interested in bioengineered river restoration. Presentations included:

1. Lake County Open Space Initiative
 - a. 2011 – Three meetings
 - b. 2012 – Three meetings
 - c. 2013 – Two meetings and one site visit in September 2013
2. September 2012 - The Implementation Team, working with Natural Resource Damage Trust

Fund for the California Gulch Superfund Site for various river restoration projects in the upper Arkansas River basin.

3. June 2013 - Kerber Creek Watershed meeting.
4. September 2013 - Natural Resource Damage Trustees Council, California Gulch Superfund Site.
5. August 2013 - Half Moon stakeholder meeting including an accompanying onsite field trip.
6. February 2014 - Mesa Land Trust meeting.
7. October 8-10, 2013 - Poster presentation at the Colorado Watershed Conference.
8. January 21-23, 2014 - Poster presentation at National Ski Area Association Winter Conference.

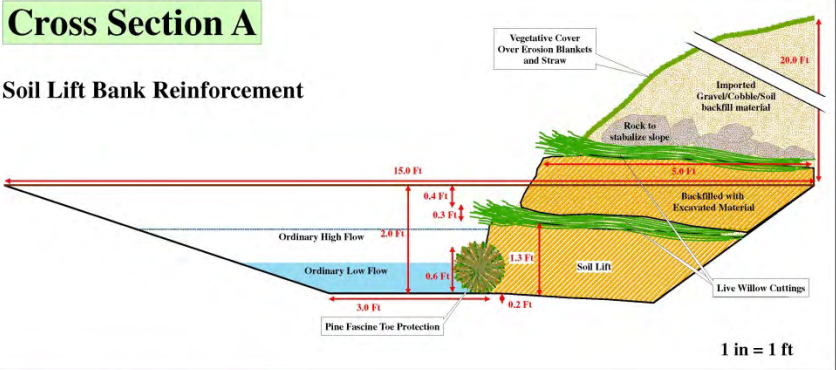
Project Design

The project design was completed by CMC and CPW after initial surveying was completed by CPW. After installation of the soil lifts, additional modifications to the design were finalized at an on-site meeting by CMC, CPW and North State Environmental. Final design included realignment of the channel near Meander 2, to move Union Creek away from the historic Leadville Stage Road. Modifications to the Meander 1 section were also included to assist with the development of fish habitat. See final maps and planning in Figure 17.

The USACE issued a Nationwide Permit No. 27 for Stream and Wetlands Restoration for the project. Additionally, right of way access permits were obtained from the two power line companies, WAPA and Excel, allowing for construction to occur.

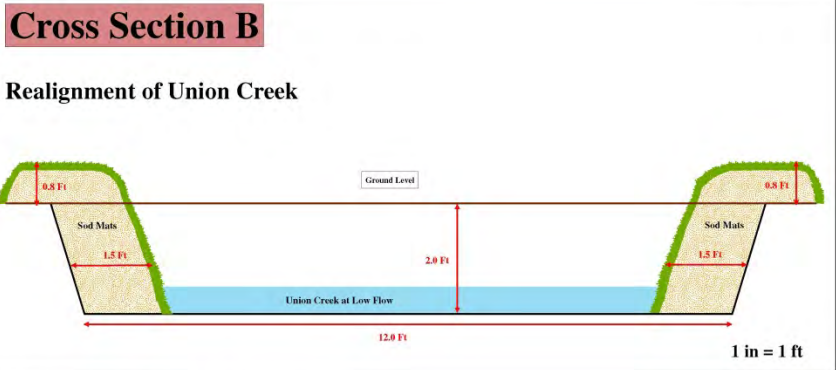
Cross Section A

Soil Lift Bank Reinforcement

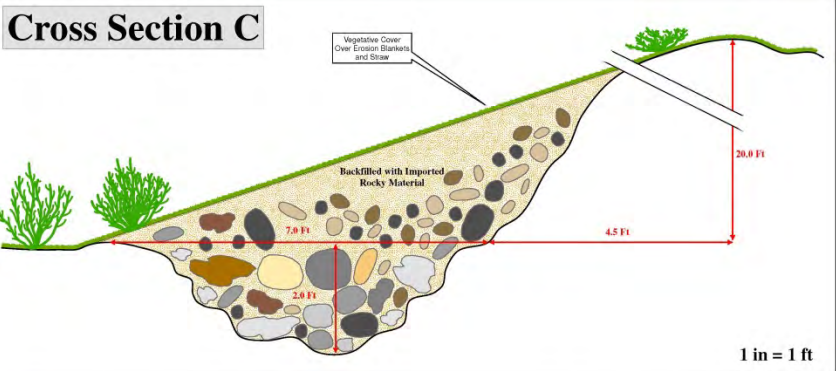


Cross Section B

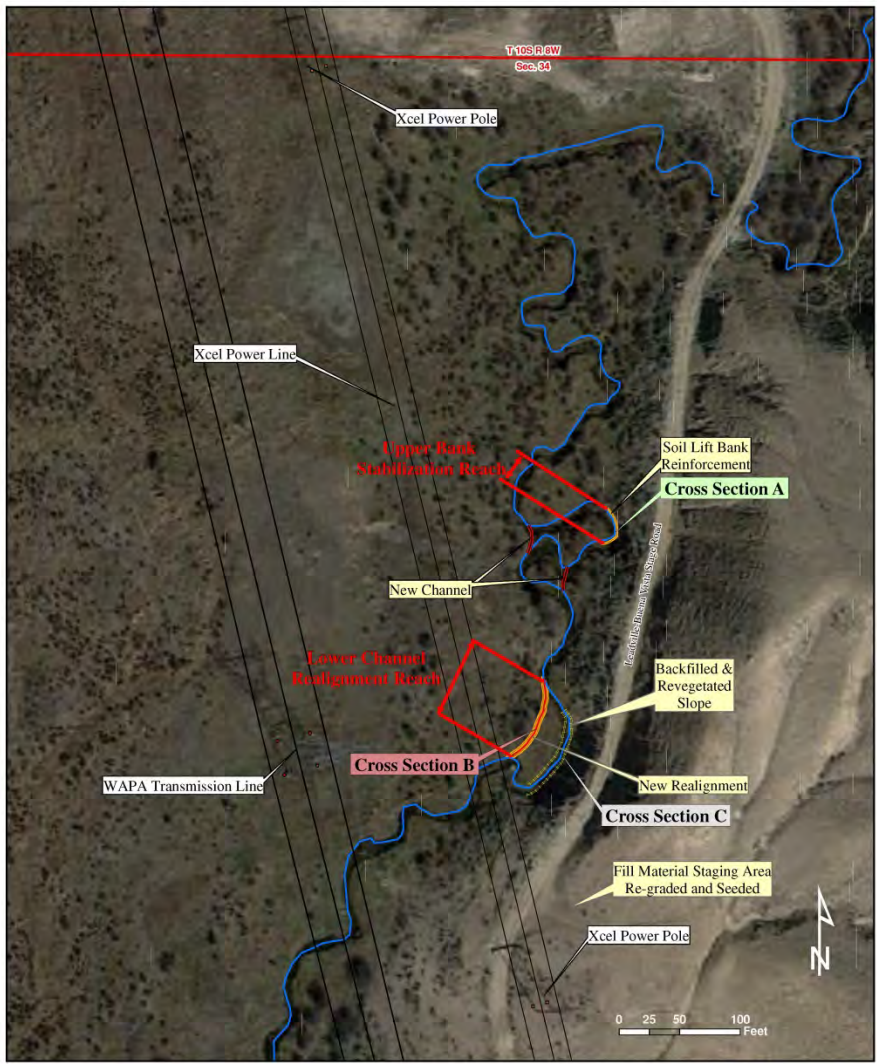
Realignment of Union Creek



Cross Section C



UNION CREEK REALIGNMENT PROJECT



Source Information
Union Creek is located south of Leadville in Lake County, Colorado. Map created by CMC NRM.
Ortho Imagery 2011
National Aerial Imagery Program
Power Poles Located by Tracy Kittell of Colorado Parks and Wildlife

LEGEND

- Soil Lift/Soil Mats
- Riprap & Soil Backfill
- Channel Relocation
- River
- Transmission & Power Lines
- Utility Pole

COLORADO



LAKE COUNTY



UNION CREEK,
LAKE COUNTY,
COLORADO



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Checked: DBKP
Revised: 4
Date: 02/25/2014

UNION CREEK STREAM RESTORATION
LAKE COUNTY, COLORADO
SOIL LIFT (PROFILE A), REALIGNMENT OF UNION CREEK (PROFILE B),
BACKFILLED ABAANDONED CHANNEL (PROFILE C)

Implementation

Project implementation began with willow harvesting in November 2012 through April of 2013. Willows were harvested from the site, as well as from the City of Aurora's Hallenbeck Ranch, and placed in snow caches at CMC to keep them dormant until construction of the soil lifts. Mobilization of the supplies for soil lift construction including Coir fabric, pine bough fascines and willows began on April 8, 2013 with construction beginning on April 15, 2013. The City of Aurora through the Otero Homestake Water Project provided personnel and heavy equipment to assist with the construction of the soil lifts. CMC NRM students and staff were joined by Trout Unlimited volunteers to construct the manual labor portion of the soil lift and CPW personnel provided technical assistance. Lake County Road and Bridge also provided heavy equipment to transport materials (soil/rock from the Arkansas River restoration project) from the west side of the Arkansas River to the east side of the Union Creek project site. The Pueblo Board of Water Works provided labor and heavy equipment to re-grade the Old Leadville Stage road on two separate occasions.

After CPW surveying was complete, an excavator cut the bench for the soil lift in the bend at Meander 1. Pine bough fascines were placed on the bench and staked into the back of the bank using guidelines (Figure 18).



Figure 18. Staking pine bough fascines to the back of the bank.

The Coir fabric, which is double layered, was unrolled on top of the pine bough fascine, filled with one foot of locally available sediment, folded back over the soil and staked to the back of the bank (Figure 19 and 20).



Figure 19. Rolling out Coir fabric on top of fascine.



Figure 20. Folding Coir fabric over soil.

Live willows were placed on top of the fabric at a frequency of one willow per inch. Three inches of soil were spread out on top of the willows. A second soil lift was installed following the same steps. In August 2013, rocks with a diameter of two to three feet were placed at the front of the soil lift and gaps

were chinked with smaller rocks and the entire slope was backfilled (Figure 21). In November 2013, the slope was dressed with straw, seed and erosion blankets (Figure 22).



Figure 21. Completed soil lift.



Figure 22. Soil lift with erosion mats at Meander 1.

Construction of the modifications around the Meander 1 area and all construction in the Meander 2 area were completed by North State Environmental on September 14 and 15, 2013. Near Meander 1, new channels were created by removing an oxbow and controlling elevations which will enhance trout habitat. A new channel was cut for Meander 2 and the abandoned channel was backfilled with large cobble. Additional topsoil was side cast from the road above to fill the channel and improve the slope of the hill. Sod mats were also placed on top of the topsoil. At the top of the abandoned channel, large mature willows and sod mats were transplanted to prevent water from flowing down the closed channel. The new channel was cut and rocks were placed on the bottom of the channel. In order to stabilize the channel, sod mats were placed on the banks. CMC NRM students and staff completed backfilling of the banks and revegetated the area by tilling in straw, spreading native upland seed mix and installing erosion mats (Figure 23).



Figure 23. Completed channel realignment at Meander 2.

NRM will conduct willow staking during the spring of 2014. Monitoring including general observations, vegetation assessment and pebble counts will occur when NRM courses are available during in 2014 and 2015.

Union Creek Stream Stabilization Project Appendix A

Baseline Data

List of Data in Appendix A

2011 Union Creek BMI Data..... 2

Union Creek Field Book..... 4

2011 Union Creek BMI Data

YR	STA	DATE	REP	BAEBIC	BAETRI	DRUDOD	SERRSP	EPELON	PARALEP	AMELET	AMPBAN	CHLORO	ISOPSP
2011	Upper		1	64	63	1	0	0	0	0	0	12	0
2011	Upper		2	17	19	0	0	1	0	0	0	6	0
2011	Upper		3	21	30	2	0	0	0	0	0	10	0
2011	Upper		4	19	19	1	0	0	0	0	0	17	0
2011	Upper		5	24	59	0	0	0	0	0	0	9	0
2011	Lower		1	34	110	0	2	0	0	0	0	18	0
2011	Lower		2	5	39	0	0	0	2	0	0	20	0
2011	Lower		3	25	56	1	0	0	0	1	0	10	0
2011	Lower		4	36	109	0	1	0	1	0	0	28	0
2011	Lower		5	18	22	0	0	0	0	0	1	23	1
YR	STA	DATE	PTEBAD	PERLODID	MICRBAC	AGABOU	GLOSSO	ARCGRA	OCHTRIC	RHYBRU	RHYSPP	TANYTA	ORTHOC
2011	Upper		0	2	2	16	0	5	24	1	0	0	84
2011	Upper		1	0	0	4	1	7	0	0	0	0	11
2011	Upper		1	0	0	8	1	33	1	2	0	0	30
2011	Upper		0	0	0	22	0	6	14	2	0	2	63
2011	Upper		0	1	2	6	0	34	4	3	0	4	45
2011	Lower		1	8	0	26	0	5	0	4	1	5	23
2011	Lower		0	3	0	54	0	0	5	0	0	9	28
2011	Lower		1	3	0	24	0	22	4	0	0	5	17
2011	Lower		1	4	1	40	0	6	2	10	0	0	27
2011	Lower		0	1	1	31	0	13	1	0	1	3	19

Union Creek Stream Stabilization Project
Final Report Appendix A

YR	STA	DATE	TANYPO	DIAMES	NEOPLAS	PERICO	SIMULI	DICRAN	HETCOR	OPTISER	CLEADD	HYDRA	GAMMSP
2011	Upper		0	102	0	0	5	1	1	125	0	0	1
2011	Upper		0	6	0	0	179	0	1	8	0	0	0
2011	Upper		0	22	2	0	169	0	0	46	0	1	1
2011	Upper		0	47	0	0	123	0	0	58	0	0	0
2011	Upper		1	43	0	1	13	0	0	65	0	0	0
2011	Lower		0	25	0	0	7	0	1	319	1	3	3
2011	Lower		1	34	0	0	0	0	0	154	0	1	8
2011	Lower		0	29	0	0	11	0	0	121	0	0	3
2011	Lower		0	30	1	1	21	0	0	385	4	4	0
2011	Lower		0	23	0	1	79	0	0	80	0	0	0
YR	STA	DATE	NEMET	OLIGOC	GYRASP	POLYCEL		Grids Sorted	Total	Total Taxa	% Heptagen		
2011	Upper		0	1	0	0		24 of 24	140	4	0.00%		
2011	Upper		0	4	0	0		24 of 24	43	4	2.33%		
2011	Upper		0	2	0	0		24 of 24	63	4	0.00%		
2011	Upper		1	27	0	0		24 of 24	56	4	0.00%		
2011	Upper		0	0	0	1		24 of 24	92	3	0.00%		
2011	Lower		1	3	0	0		24 of 24	164	4	0.00%		
2011	Lower		1	30	1	1		24 of 24	66	4	0.00%		
2011	Lower		0	0	0	0		24 of 24	93	5	0.00%		
2011	Lower		0	0	0	1		24 of 24	175	5	0.00%		
2011	Lower		1	0	0	0		24 of 24	65	5	0.00%		

Union Creek Field Book



Name... CMC / NRM

Address... 901 S HWY 24
LEADVILLE, CO 80461

Phone... 719.480.4239

Projects... UNION CREEK

Bank Code - 7289

NAPA
1800.835.0547

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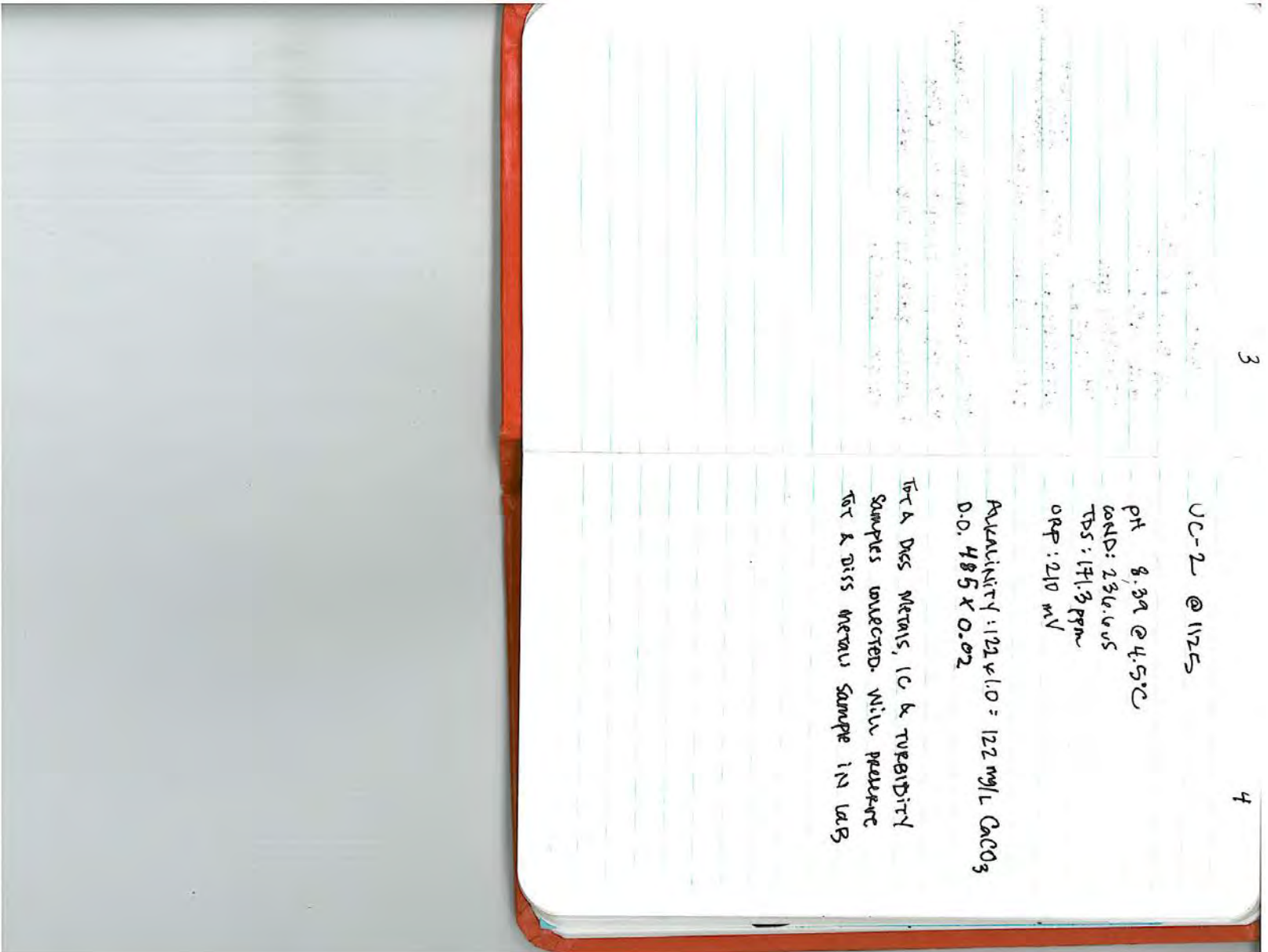
Projects (continued)

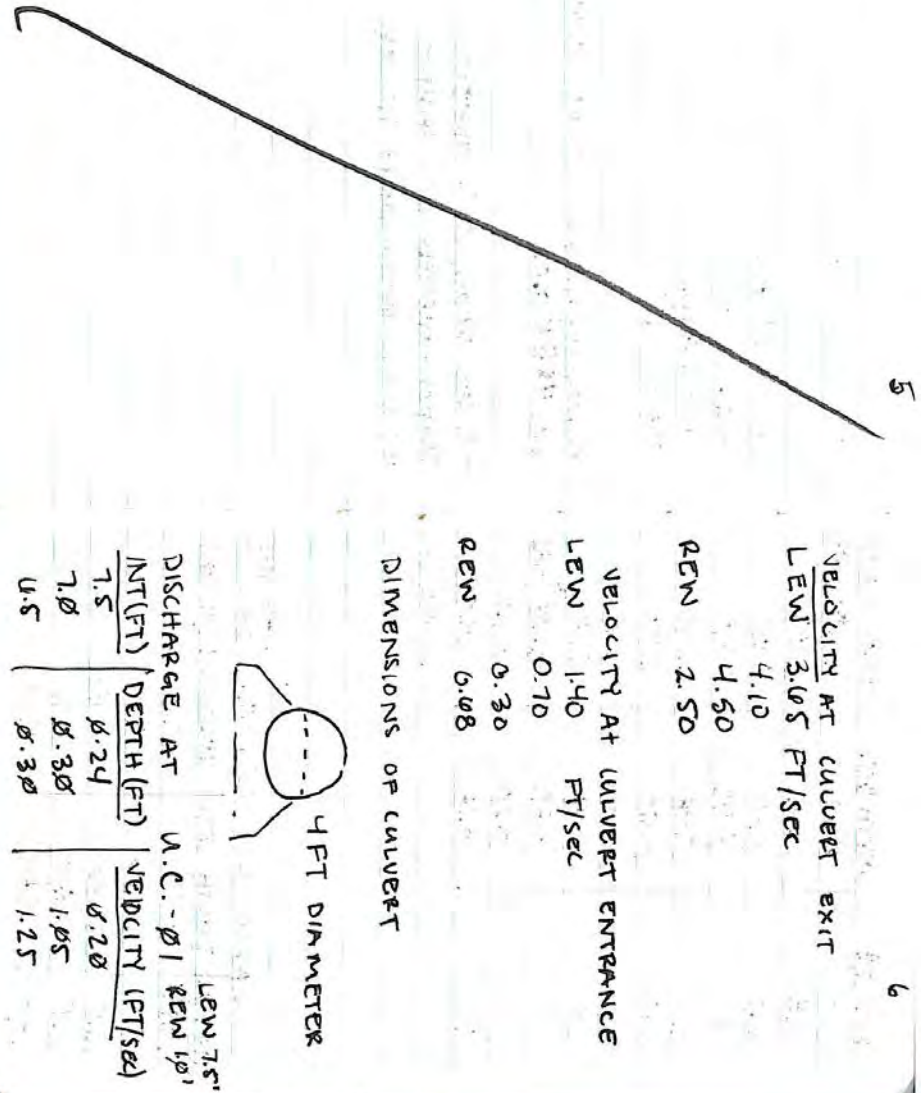
Table of Contents

Date	Event	Page #
4/15/11	Union Creek Stabilization	1
6/23/11	UC Discharge	14
6/30/11	UC Discharge	16
7/8/11	UC Discharge	18
7/14/11	UC Discharge	22
8/5/11	UC Discharge	24
10/3/11	UC Design & Survey	30
6/4/12	Soil Leachate	124
4/15/13	UC Construction	38
4/16/13	UC Construction	39
5/16/13	Site Visit	40
5/24/13	Site Visit	42
7/1/13	Survey Slopes	44

4/15/11 UNION CREEK
 TIME: 840
 WEATHER: MOSTLY SUNNY, HIGH
 NEAR 80°F, NW WIND 15-20 mph
 WIND CHILL 6-10°
 TEAM: C. BORBELY, Mth: S. HUTCINSON,
 M. WOLFE, T. COOPER, J. FRANKLIN,
 T. MEULET, K.
 - VECCHIO, J. KNISS
 EVENT: UNION CREEK STABILIZATION
 PROJECT
 PURPOSE: COLLECT / ESTABLISH
 BASELINE DATA FOR U.C. PROJECT
 EQUIPMENT MYRON SN# 22006110
 MARSH MCBENNEY SN# 22006110
 TITRATION KITS: AXK & D.O.
 CALIBRATION CHECK
 PH: 4.0 → 4.07 COND 147 → 451 f/s
 7.0 → 4.98 1.03 04.9
 10.0 → 10.04 04.9

UC-ABOVE 1010 / UC-1
 PH: 8.12 @ 2.9°C
 COND: 289.9 US
 TDS: 173.6 ppm
 ORP: 237 mV
 ALKALINITY: 130 mg/L (1.000 NaOH
 100 mL light-violet blue grey)
 D.O: 302 x 0.02 = 6.04 mg/L
 TOT & DISS. METALS SAMPLE & LC SAMPLE
 COLLECTED. WILL PRESERVE TOT & DISS
 METALS BACK IN LAB. TURBIDITY
 SAMPLE COLLECTED.





7

INT (FT)	DEPTH (FT)	VELOCITY (FT/SEC)
4.0	0.32	1.285
5.5	0.42	1.90
5.0	0.40	1.95
4.5	0.42	1.89
4.0	0.48	2.00
3.5	0.50	2.20
3.0	0.30	1.00
2.5	0.48	1.98
2.0	0.32	0.98
1.5	0.20	0.82
1.0	0.18	0.22

3.76 cfs 1K

8

INT	DEPTH	VELOCITY
9.5	0.42	0.51
8.5	0.58	0.55
7.5	0.60	0.65
6.5	0.85	0.55
5.5	0.42	0.18
4.5	0.02	-0.15
4.0	0.0	0.0

2.35 cfs 1K

VELOCITY MEASUREMENTS BETWEEN
MEANDERS 3 & 4

START AT DOWN-
STREAM MEANDER
4 BUT BEFORE UC-2

MIDDLE OF M. 4

0.80
0.80
1.45
1.20
0.85
0.80
1.45
1.98
1.35

AREA OF EROSION

AREA OF EROSION

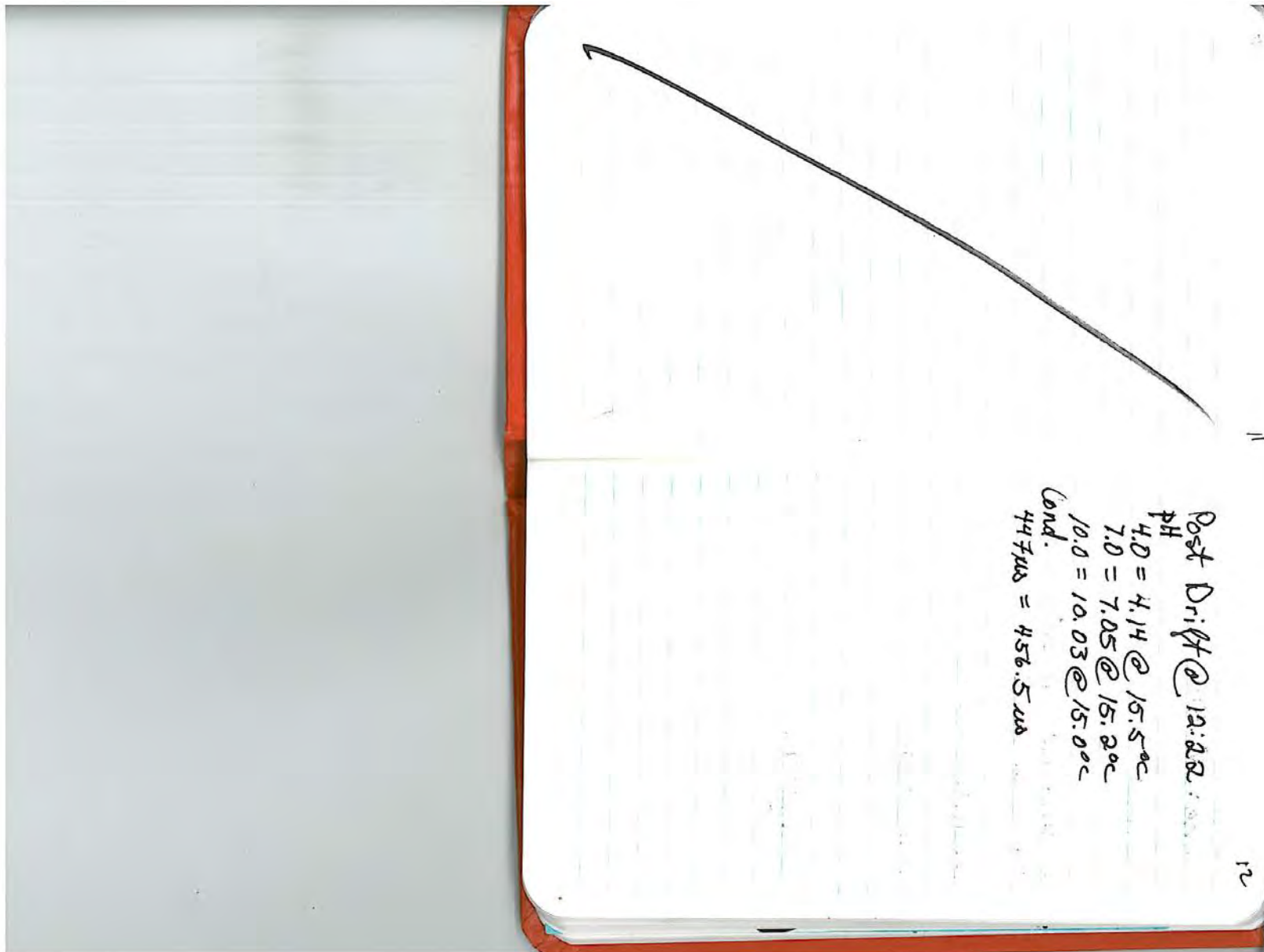
DISCHARGE AT U.C. - 02

LCW 14.5'

RCW 4.0'

INT (FT)	DEPTH (FT)	VELOCITY (FT/SEC)
14.85	0.14	-0.14
13.5	0.30	0.01
12.5	0.40	0.40
11.5	0.60	0.70
10.5	0.80	0.45

Area of erosion	VELOCITY (FT/SEC)
MIDDLE OF M. 3	1.40
END UP STREAM OF	1.00
MEANDER 3 BUT	0.70
BEFORE MEANDER 2	0.90
	1.45
	1.00



Union Creek
time: 2/14/50
Weather: ...
Team: M. Wolf, N. Giffard
W. Middlebrook
Event: Discharge
Purpose:
Equipment

13

Interval	discharge	depth	velocity	notes
3.0	1.4	2.70		
3.3	1.54	3.33		
3.6	1.6	3.7		
3.9	1.6	3.35		
4.2	1.64	3.8		
4.5	1.6	3.7		
4.8	1.6	3.64		
5.1	1.46	3.52		
5.4	1.44	3.50		
5.7	1.34	3.10		
6.0	1.2	3.04		
6.3	1.14	2.85		
6.6	1.1	3.20		
6.9	1.05	3.15		
7.2	1.06	3.07		
7.5	1.06	3.0		
7.8	1.0	2.8		
8.1	1.0	2.7		
8.4	0.9	1.7		
8.7	0.86	0.13		
9.0				

14

6.6 1.2 3.15

7.8 3.1

Interval	Depth	Velocity
12.5	1.2	1.28
13	1.0	1.04
13.5	1.0	0.68
14	0	0

27.04.48

17

7-8-11 Discharge Monitoring
Time: 0905

Team: J. Franklin
N. Griffland

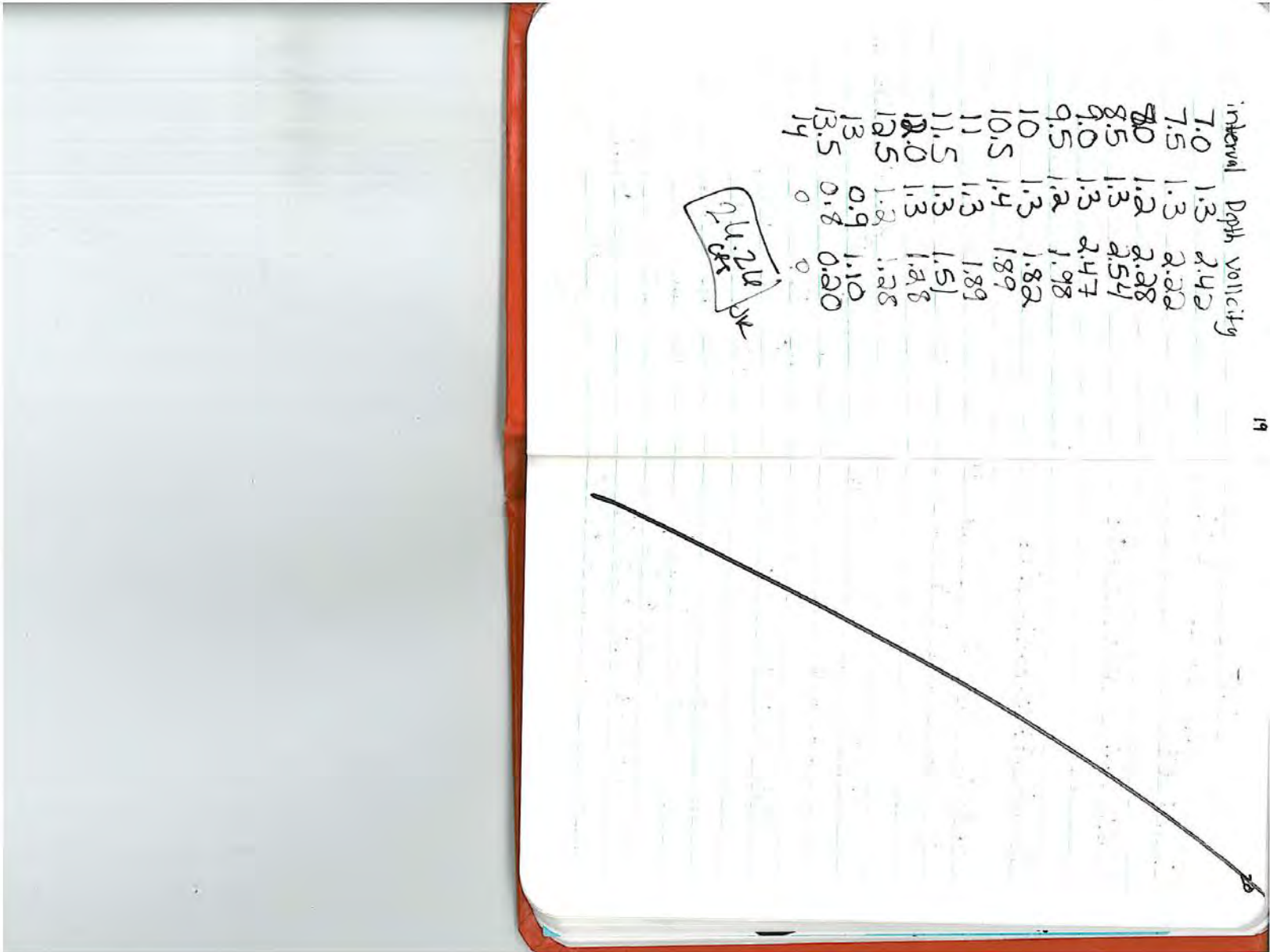
Purpose: Measure discharge
@ WC-2

Weather: 55°F, High of 74°F
No birds in past 24-hr

Precip

Interval depth velocity
0 0 Rev 14 ft LBW 2 ft

2.5	0.72	-0.33
3.0	0.8	-0.29
3.5	1.0	1.54
4.0	1.1	2.17
4.5	1.2	2.40
5.0	1.3	2.33
5.5	1.4	2.35
6.0	1.4	2.92
6.5	1.3	2.78



UNION CREEK DISCHARGE & V.C. DISCHARGE & BM1 7/14/11²¹

TIME: 1330

WEATHER: SUNNY, PARTLY CLOUDY

TEAM: J. FRANKLIN, J. KNISS

PURPOSE: MEASURED DISCHARGE GUC-2, SAMPLE BM1 & WQ

EQUIPMENT: MYRON ULTRAMETER SN# 0225207

MARS4 SN# 2006810

CAL. CHECK:
 pH: 4.00 → 4.03 @ 19.6°C
 7.00 → 7.04 @ 19.6°C
 10.00 → 10.00 @ 19.6°C
 COND: 447 uS → 447.0 uS @ 19.7°C

INT	DEPTH (FT)	VELOCITY (CMS)
2.0	0.0	0.0
2.5	0.6	-0.20
3.0	0.7	0.11
3.5	1.0	1.13
4.0	1.0	1.30
4.5	1.1	1.55
5.0	1.2	1.87
5.5	1.3	1.46
6.0	1.2	2.08
6.5	1.2	1.74
7.0	1.1	1.00
7.5	1.1	1.33
8.0	1.2	1.43
8.5	1.1	1.88
9.0	1.1	1.79
9.5	1.1	1.57
10.0	1.1	1.40
10.5	1.1	1.38
11.0	1.1	1.37
11.5	1.1	1.16

REW: 14.0 FT LEW: 2.0 FT

23

INT	D (ft)	Vel. (cfs)
12.0	1.1	1.22
12.5	1.0	0.81
13.0	0.7	0.81
13.5	0.7	0.02
14.0	0.0	0.0

110.15 cfs
34

7 DID NOT FIND END TO
WILCO = COULD NOT SAMPLE
BML

EDDS: MEASURED DISAPPEAR UP
W/OUT INCIDENT. COULD NOT
SAMPLE BML DUE TO LOST
END COLLECTOR FOR WILCO

8-5-11 24

Union Creek

time: 11:35

Weather
Wet

Team: NantHaul STANKU,

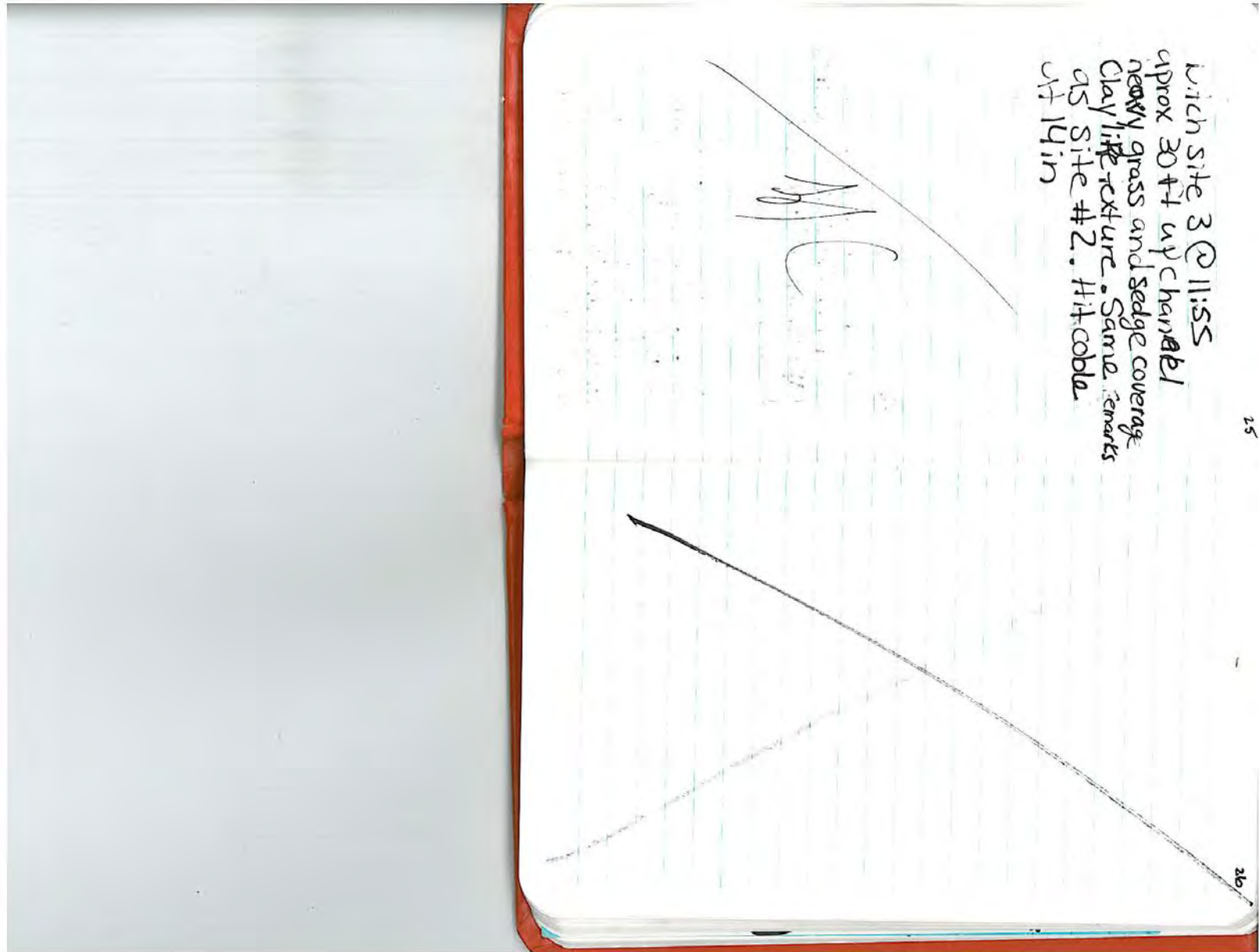
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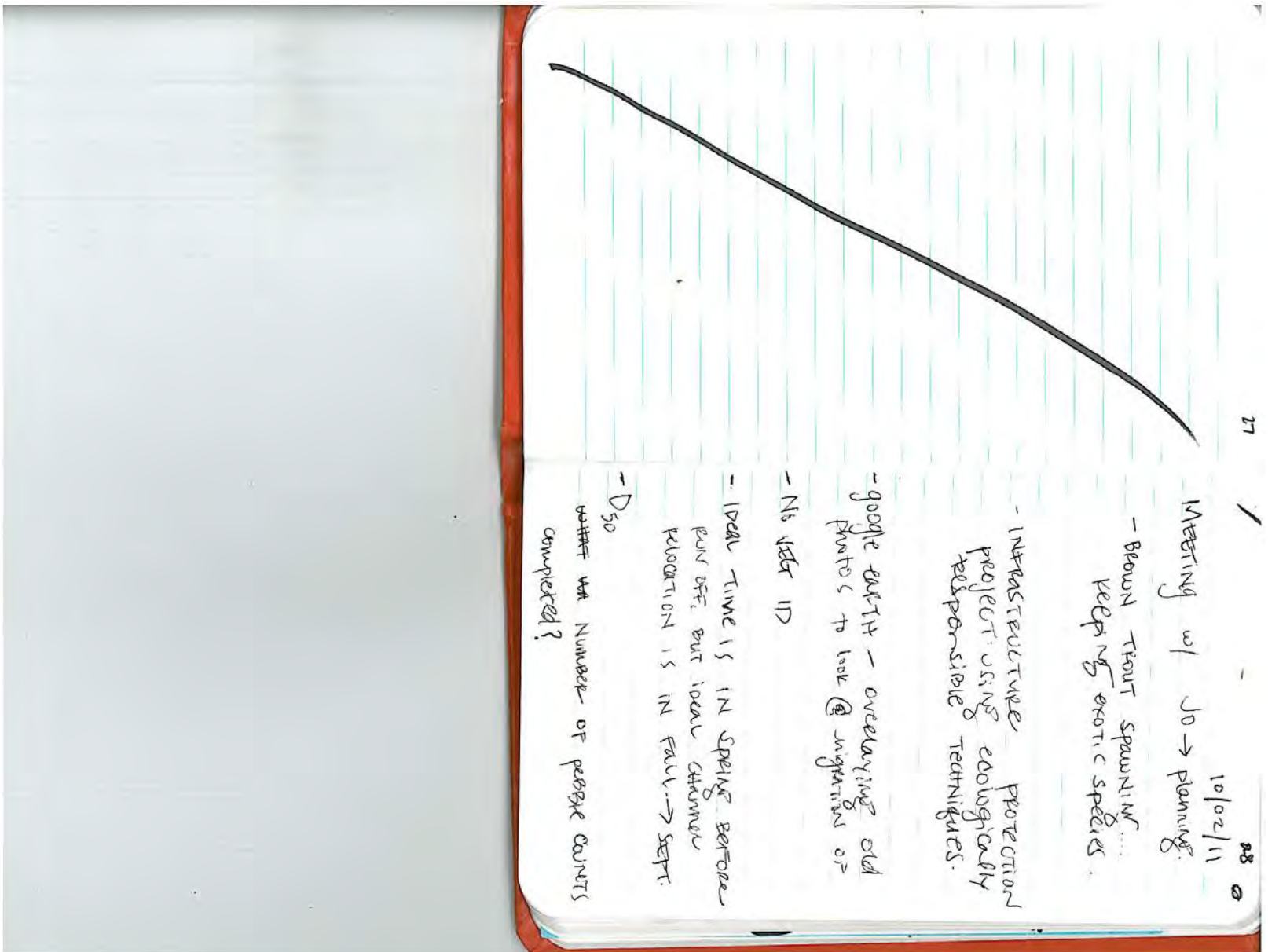
Ditch site 1 @ 11:40

Site near exit of Ditch
3in of soil before hitting
coble. Clay like texture
approx. 2in of organic
matter.

Ditch site 2 @ 11:45

approx. 40 ft up channel
heavy grass/sedge coverage
soil is saturated. Heavy
organic matter. Hit water
table at 8in. Hit cobble
at 12in.





27

Meeting w/ JO → planning.

10/02/11

28

- Brown Trout spawning...
keeping exotic species.

- Infrastructure protection
project using ecologically
responsible techniques.

- Google Earth - overlaying old
photos to look @ migration of

- Nis Veta ID

- Ideal time is in spring before
run off, but ideal summer
relocation is in fall → Sept.

- D₅₀
what the number of pebble counts
completed?

29

* 1st/2nd meet of WAPAC is
Bitterroot River Project. *

→ channel relocation design by
Tracy
Bank design by Jo

- * Soil Corep
- WADERS
- WATER JUG
- GPS
- CANISTER

Site Visit @ Union Creek

DATE 10-03-11

TEAM: J. CHRISTENSEN, T. KITTEL,
J. (POW-HUNT EQ), J. DORAN
(geometrics), J. KNUSS, J. M.
M. WOLFE, M. CONLID, R. WHITE

Purpose: DESIGN & SURVEY

OPTION DESIGN

- ① MORE ROAD
 - ② HARD ARMORING
 - ③ RELOCATE CHANNEL
 - ④ REVEG BANKS
- TOO STEEP

QUESTIONS

- ETCEL RIGHT OF WAY
- LENGTH OF MONKEY FOR GRANT
- GRANT FOR JO'S RELEASE TIME



31

SHORT GROUND OPTION FOR BUTTER-POND
REMOVAL

- reference of existing stream

likely leaving point 15-28

32

UNION CREEK

Excel energy

1800-628-2121

119-486-2325

Quaker Ship

- HYPHEN PUNCT

- PAPERWORK

- BURN IN 2008

970 485 5930 -- Megan Kelle

April 7260 very distant

7260 Christen Mullany

970 202 4024 W 1

0404-12

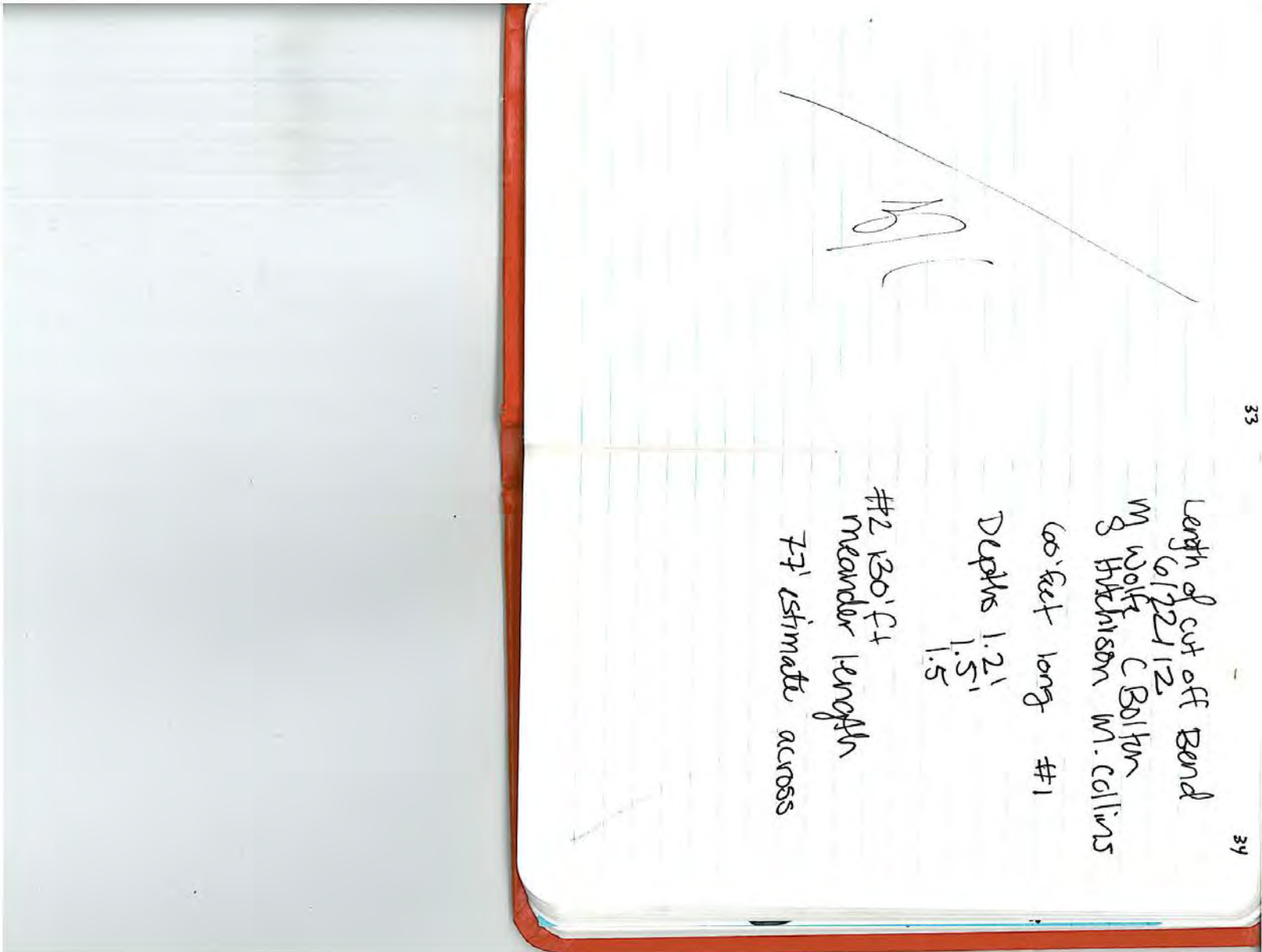
AT 320

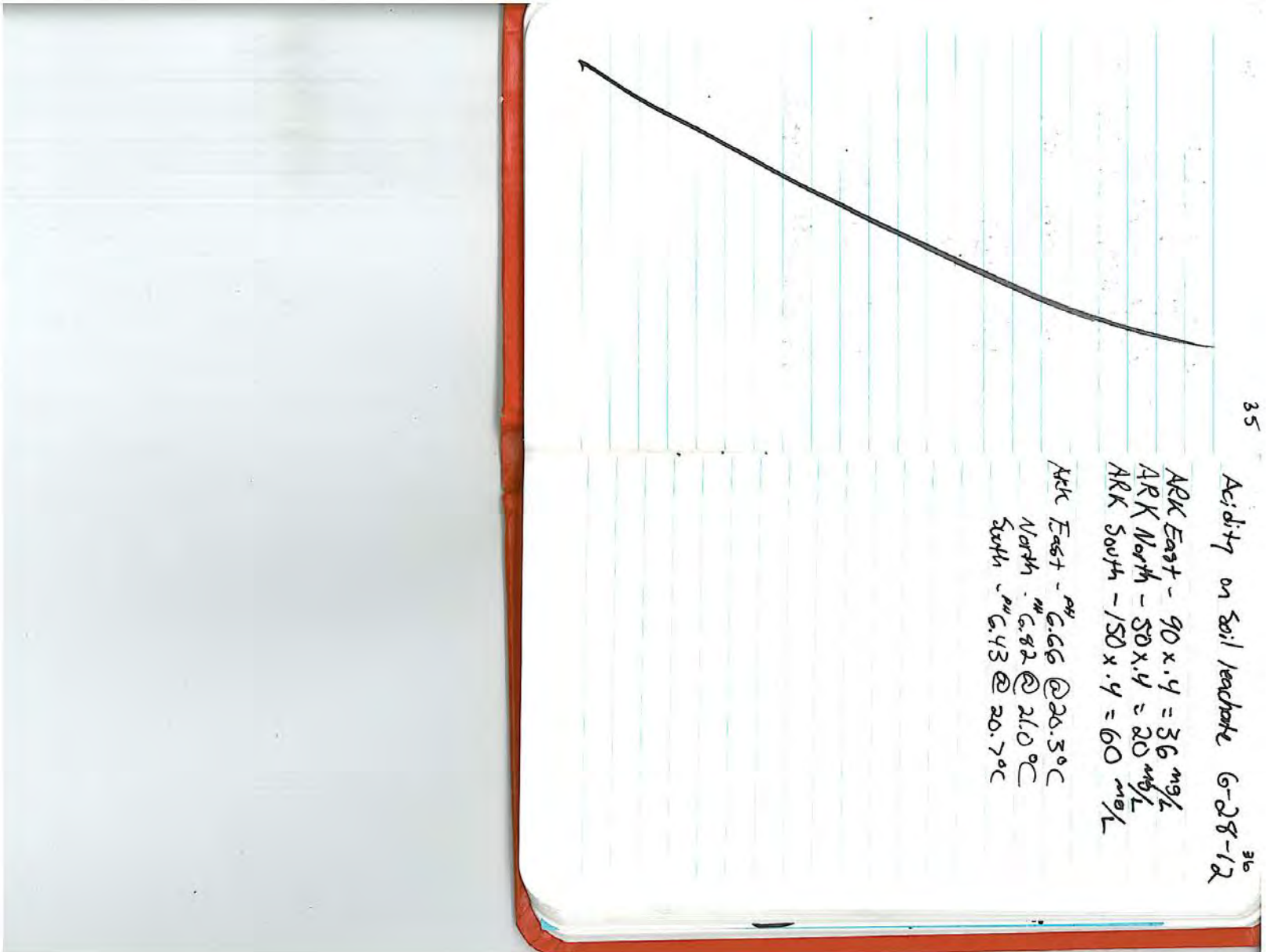
FOR EXCAVATOR & FRONT END
4' wide bucket waste

1 y/c 704.604.3829

Dream

lined to TOP & BOTTOM
drainage & export to
areas





37

4-15-13

Construction

- Material onsite as of 4/12
- 1 Rot 7'x165' BioD Mat 90%
- 1 Rot Excel CC 9 Coconut bulkhead
- 1 pile of pine boxes for gabion

Long Mat

4/15 personnel working on project

J. Madenauer	7:30-5:18
J. Moore	11:00-6:00
D. Pedersen	1:30-5:45
R. Walker	1:30-5:45

- Transported Willow over site
- Constructed pine box gabion
- Staked in "
- Otero Day in beach for soil test
- 2 men from Otero
- 015, 49 9:30-10:30

38

4-16-13

Personnel Onsite

S. Moore 7:45 - 5:30
S. Moore 7:45 - 3:45
A. Padgett 8:00 - 12:45
T. Lehto 7:45 - 3:45
R. Walker 8:00 - 3:45
S. Walker 9:00 - 3:45
• Rained out 80 cubic bags 1st day
• Offense Filled left w/ sand
• 1st w/ Trout Unlimited Team
• 2nd w/ completed 2 sand
• 3rd. Used 21,000 inches for
55-foot section.

39

Site Visit @ Union Creek

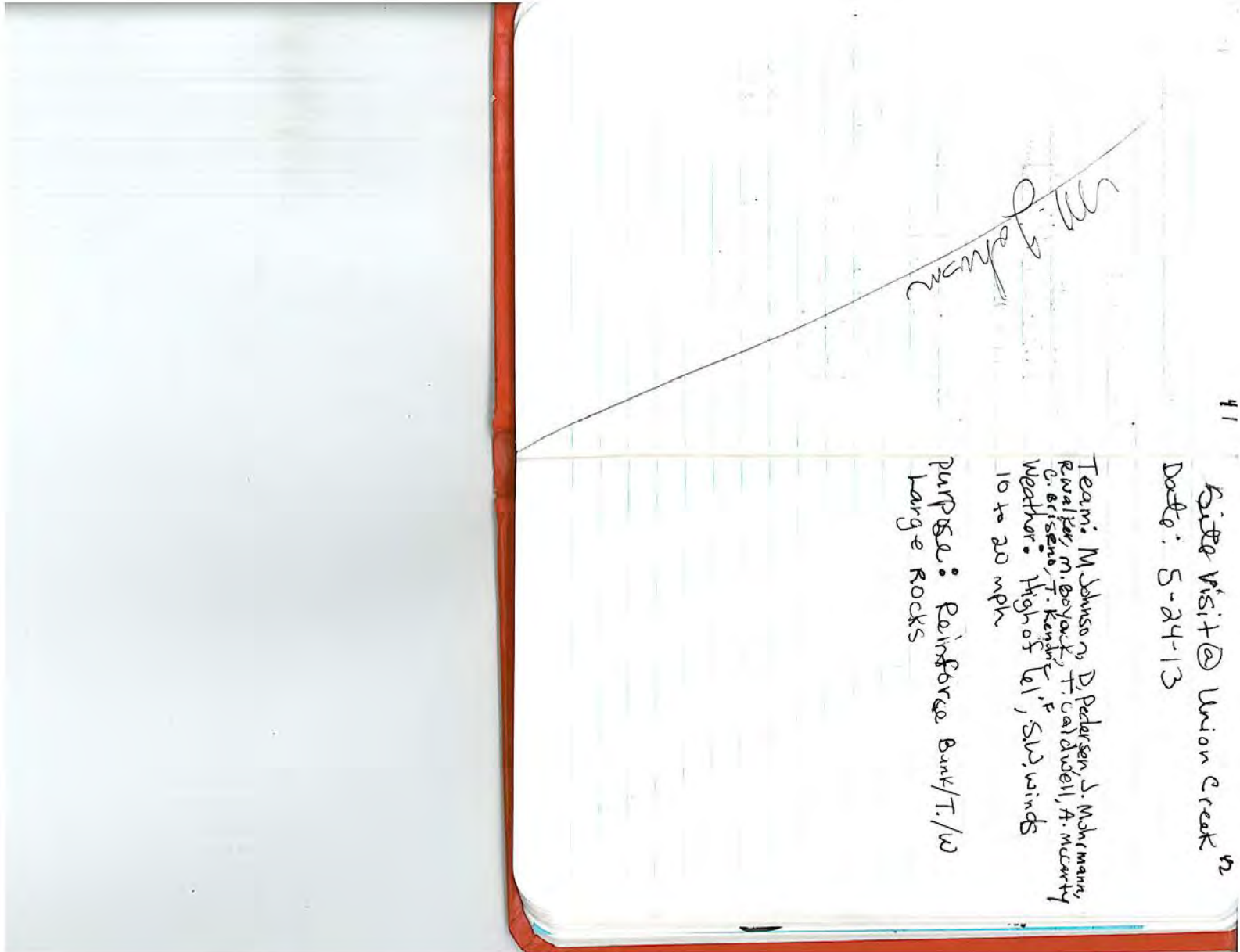
Date: 5-16-13

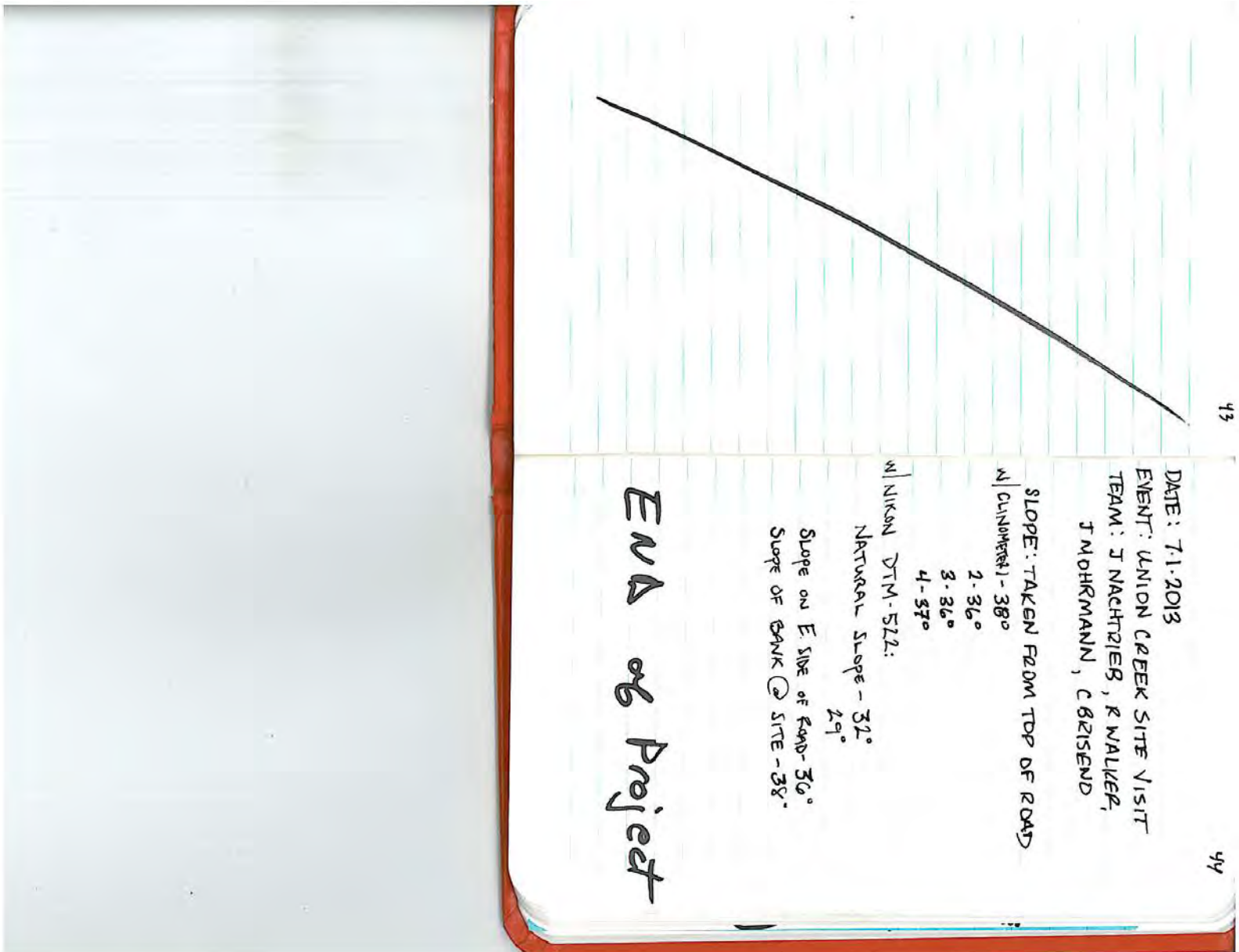
Team: J. Moore, R. Walker
M. Bayack, T. Caldwell
A. Malarkey

Purpose: Reinforce tow w/
Big Rocks

Then hauled 3 loads of
Rocks to the Union Creek
Site. We then precisely
placed the Rocks along
the tow to help reinforce
the streambank.

40





Union Creek Stabilization Project

Appendix B

Photo Documentation

List of Figures

Union Creek Photo Point Documentation

Figure 1. Photo Point 1 - Meander 1 Pre Construction.....	2
Figure 2. Photo Point 1 – Meander 1 Post-Construction	2
Figure 3. Photo Point 1a- Meander 1, location of soil lift installation seen between arrow points.	3
Figure 4. Photo Point 1a – Meander 1, Post Construction.....	3
Figure 5. Photo Point 2 - Meander 2, pre-construction.....	4
Figure 6. Photo Point 2 – Meander 2, post construction.....	4
Figure 7. Photo 2b- Location of channel realignment point of exit and re-entry. Pre-construction	5
Figure 8. Photo 2b- Channel realignment post-construction.	5

Additional Union Creek Photos

Figure 9. Reclamation Site Monitoring class completing Wolman Pebble count and water quality sampling.	6
Figure 10. Reclamation Site Monitoring class conducting stream flow measurements.	6
Figure 11. Measuring fish length and type with USFWS personnel.	7
Figure 12. Fish Shocking with USFWS personnel.	7
Figure 13. Field Monitoring Technique class measuring discharge.	8
Figure 14. Surveying the bank bottom at Union Creek with CMC, CPW and US BLM Montana personnel.....	8
Figure 15. Survey and stream restoration workshop with CMC, US BLM Montana and CPW personnel.....	9
Figure 16. Students from urban Denver looking at BMI from Union Creek.	9
Figure 17. Demonstrating BMI sampling to Colorado UpLift students.	10
Figure 18. Willow harvesting in preparation of soil lift construction with Advanced Hydrology students, March, 2013.	10
Figure 19. Snow caching willows with Advanced Hydrology students. March, 2013.....	11
Figure 20. Soil Lift construction. April, 2013	11
Figure 21. Soil Lift construction. April, 2013	12
Figure 22. Soil Lift construction. April, 2013	12
Figure 23. Willow growth in soil lift May, 2013. Note pine bow fascine below water.....	13
Figure 24. Soil Lift willows with 8 weeks of growth.	14
Figure 25. Same soil lift willows after 11 weeks.....	14
Figure 26. Same soil lift willows after 21 weeks.....	14
Figure 27. Laying sod mats and willow transplants near Meander 2.	15
Figure 28. Relocating a willow to stabilize a new bank near Meander 2.	15
Figure 29. Lining out the new channel.	16
Figure 30. Two of the three excavators working in the Meander 1 Area.	16
Figure 31. Panorama view of the project site.	17
Figure 32. Re-graded Meander 1 Soil Lift area.	17
Figure 33. Log diversion structure used to divide flow into two separate channels creating better fish habitat.	17

Union Creek Photo Point Documentation



Figure 1. Photo Point 1 - Meander 1 Pre Construction



Figure 2. Photo Point 1 – Meander 1 Post-Construction



Figure 3. Photo Point 1a- Meander 1, location of soil lift installation seen between arrow points.



Figure 4. Photo Point 1a – Meander 1, Post Construction.
Note closer of oxbow at orange arrow, new elevation control ripple is behind large transplant willow.



Figure 5. Photo Point 2 - Meander 2, pre-construction



**Figure 6. Photo Point 2 – Meander 2, post construction.
Backfill is approximately 60% complete in this picture**



Figure 7. Location of channel realignment point of exit and re-entry. Pre-construction



Figure 8. Photo 2b- Channel realignment post-construction.

Additional Union Creek Photos



Figure 9. Reclamation Site Monitoring class completing Wolman Pebble count and water quality sampling.



Figure 10. Reclamation Site Monitoring class conducting stream flow measurements.



Figure 11. Measuring fish length and type with USFWS personnel.



Figure 12. Fish Shocking with USFWS personnel.



Figure 13. Field Monitoring Technique class measuring discharge.



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Figure 15. Survey and stream restoration workshop with CMC, US BLM Montana and CPW personnel.



Figure 16. Students from urban Denver looking at BMI from Union Creek.



Figure 17. Demonstrating BMI sampling to Colorado UpLift students.



Figure 18. Willow harvesting in preparation of soil lift construction with Advanced Hydrology students, March, 2013.



Figure 19. Snow caching willows with Advanced Hydrology students. March, 2013



Figure 20. Soil Lift construction. April, 2013



Figure 21. Soil Lift construction. April, 2013



Figure 22. Soil Lift construction. April, 2013



Figure 23. Willow growth in soil lift May, 2013. Note pine bow fascine below water.



Figure 24. Soil Lift willows with 8 weeks of growth.

Figure 25. Same soil lift willows after 11 weeks.



Figure 26. Same soil lift willows after 21 weeks.

Figure 27. Laying sod mats and willow transplants near Meander 2.



Figure 28. Relocating a willow to stabilize a new bank near Meander 2.



Figure 29. Lining out the new channel.



Figure 30. Two of the three excavators working in the Meander 1 Area.



Figure 31. Panorama view of the project site.



Figure 32. Re-graded Meander 1 Soil Lift area.



Figure 33. Log diversion structure used to divide flow into two separate channels creating better fish habitat.