2014 Dolores River Cottonwood Suitability Assessment

ACKNOWLEDGMENTS

This report was developed in April/May 2014 and was a collaborative effort by project interns Theresa Ruswick and Kelly O'Neill (of Southwest Conservation Corps) and project co-coordinators Mike Wight (Corps River Restoration Director of the Southwest Conservation Corps) and Julie Knudson (Staff Scientist for the Tamarisk Coalition).

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For further information on this project, please contact the Tamarisk Coalition, Grand Junction, Colorado.

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INTRODUCTION

The Dolores River Restoration Partnership (DRRP) has been working to restore the Dolores River riparian corridor by removing significant infestations of woody and herbaceous invasive species and actively revegetating these sites with more desirable/native plant species. A portion of this active revegetation effort has been devoted to restoring native willows and cottonwoods along stretches of the river. Some initial attempts to establish these species were successful, but other attempts were not successful. The following study originated out of a desire to increase the survival/success rate of cottonwood and willow plantings along the Dolores River, as well as to help develop a streamlined protocol that others could use to enhance success of their plantings on other rivers across the West.

It is important to note that while the Dolores River is indeed witnessing natural recruitment of cottonwoods in some areas, many of the sites where landowners would like to see cottonwoods re-established are sites that may still support cottonwood growth (e.g. relatively shallow water tables, low enough salinity levels), but these sites no longer (or very rarely) experience the scouring flows required to create an adequate seedbed for natural cottonwood establishment, mostly as a result of regulated flows on the river. Thus, land managers who would like to see cottonwoods re-established on their sites as a part of the active restoration effort for reasons such as wildlife habitat, aesthetics, or shade for recreationists must actively plant desired trees.

For this assessment, BLM Field Office managers from Grand Junction and Uncompahgre, along with several private landowners, selected priority sites along the Dolores River where cottonwood planting was desired for the above listed reasons but trees were unlikely to establish on their own. From February to mid-March 2014, soil and water were sampled on twenty sites, and deep-pole planting of cottonwoods was conducted if conditions were conducive to cottonwood growth. Groundwater wells were installed on several sites in order to monitor annual and seasonal fluctuations in groundwater levels. Additionally, shallow whip sampling was conducted on four sites within the jurisdiction of the Grand Junction BLM Field office to provide additional soil data for potential future native planting sites.

The project was conducted throughout a 124 mile span of the Dolores River, between the town of Slick Rock in Colorado and the confluence with the Colorado River in Utah. Overall, 231 holes were sampled, 116 cottonwood trees were planted, and 7 groundwater monitoring wells were installed. Figure 1 shows the location of the sites involved in the 2014 Cottonwood Suitability Assessment. Soil salinity, water salinity and water table depth on these sites are summarized in Table 1 and shown in graph form (Figure 2).

Figure 1: 2014 Cottonwood Suitability Assessment Sites along the Dolores River

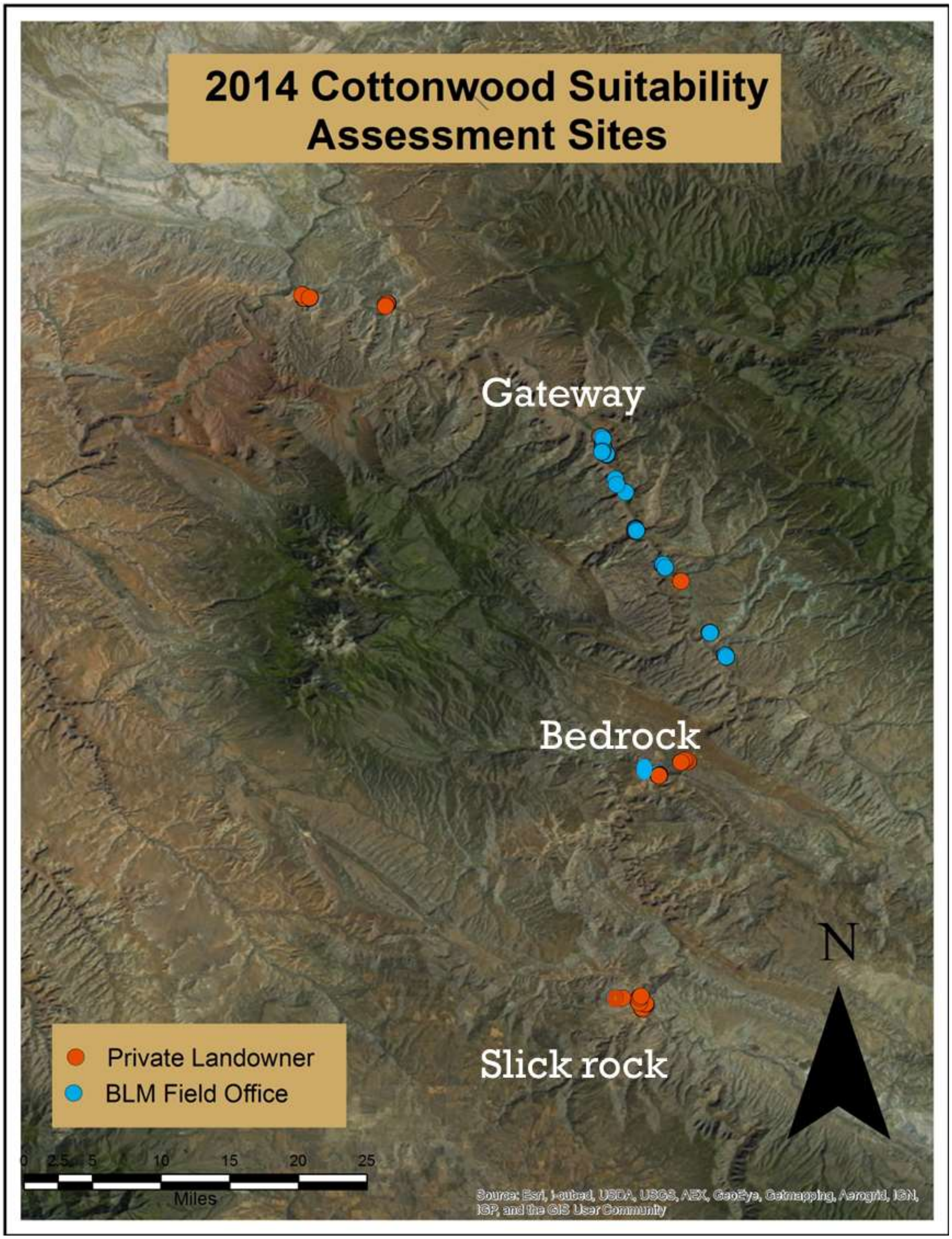


Table 1: Soil salinity, water salinity, and water table depth on sites along the Dolores River

Property	PLBE	PLRO		UFO	PLPH		Uncompahgre Field Office(UFO)				PLBU
Site Name	PLBE	PLRORO	PLRONI	Boatramp	PLPHPR	PLPHPO	Bridgetest1	Bridgetest2	Hwy141Test1	Hwy141Test2	PLBU
Deep Sampling Sites	A	B	C	D	E	F	G	H	I	J	K
Avg Soil Salinity at Surface	0.41	1.12	1	0.48	0.57	0.87	0.82	0.71	0.35	0.3	0.94
Avg Soil Salinity at Depth(6-8 ft)	0.82	3.64	3.21	2.56	0.35	1.5	1.35	0.69	1.17	0.36	2.02
Avg Water Salinity Pit Water	0.94	7.42	6.84	2.29	0.68	13.35	1.7	1.07	2.47	3.06	1.56
Water Salinity River	0.59	1.13	1.13	1.13	1.08	1.08	1.35	1.35	1.37	1.37	1.23
Avg Depth to Water Table(ft)	7.5	6.04	6.75	7.75	5.86	6.5	7.2	7.4	7.8	8	5.43

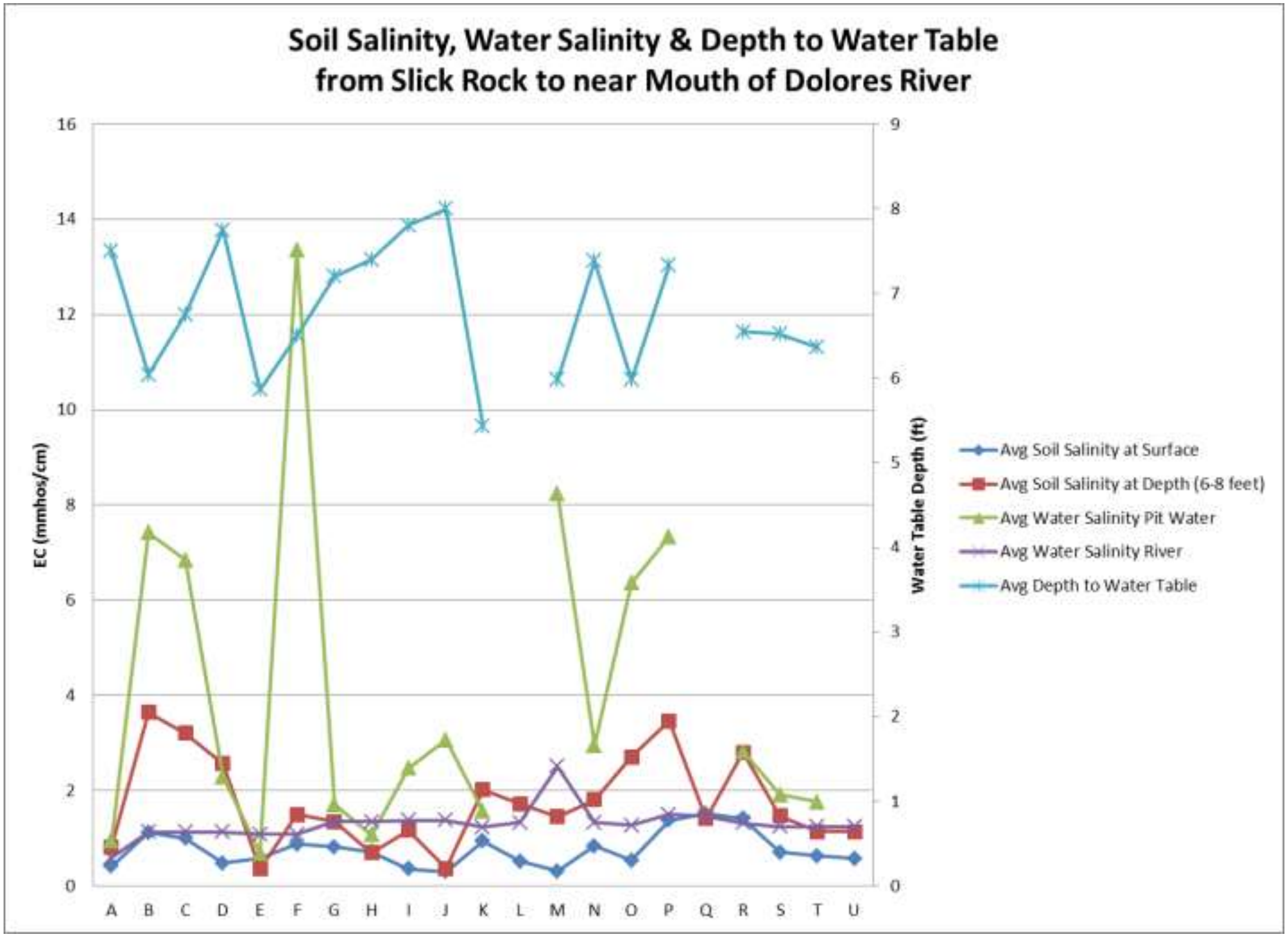
Property	Grand Junction Field Office							Rio Mesa		LABO
Site Name	131arlPVT	PetDeep	CCBLM04	OP7	OP2	139SOUTHRL	139NORTHRR	Groupcamp1	Groupcamp2	LABO
Deep Sampling Sites	L	M	N	O	P	Q	R	S	T	U
Avg Soil Salinity at Surface	0.51	0.31	0.84	0.53	1.37	1.52	1.41	0.7	0.63	0.57
Avg Soil Salinity at Depth (6-8 ft)	1.72	1.45	1.81	2.71	3.46	1.41	2.8	1.47	1.14	1.14
Avg Water Salinity Pit Water	No Water	8.23	2.95	6.36	7.33	No Water	2.82	1.91	1.76	No Water
Water Salinity River	1.33	2.51	1.33	1.27	1.5	1.46	1.32	1.24	1.24	1.24
Avg Depth to Water Table(ft)	No Water	5.98	7.38	5.98	7.33	No Water	6.55	6.52	6.36	No Water

*Letters were assigned to the deep sampling sites based on location along the Dolores River from furthest upstream to furthest downstream (i.e. 'A' is located near Slick Rock, 'U' is located near the mouth of the Dolores River). The letters correspond to the graph below (Figure 2).

**Salinity (EC) values above and throughout this report are expressed as mmhos/cm, where EC = mS/cm = mmhos/cm.

*** The 'PL' sites and some of the other coded sites are private landowner sites that have been abbreviated.

Figure 2: Soil Salinity,Water Salinity and Water Table Depth from Slick Rock to near Mouth of Dolores River.



METHODOLOGY

Data Collection Electronically: Using MapitFast/Strider Software: All the data was collected electronically in MapitFast. Base maps were preloaded and used for navigation in the field. MapitFast recorded the locations (latitude and longitude) of the sampling points in WGS84. The sampling points were recorded. All data was loaded onto the MapitFast cloud and organized in Strider Software. (See Appendix A for more detail).

Shallow Sampling: For shallow sampling, soil pH, salinity, and texture were tested at three depths (0-6 inches, 6-12 inches, and 12-36 inches respectively) within hole. (See Appendix B for more detail).

Deep Sampling: Deep sampling was used to identify groundwater depth, pH, and salinity. Additionally, the soil pH, soil salinity, and soil texture were tested at three depths (bottom, midpoint, top) of hole. A mini-excavator with stinger attachment was used to drill 8 foot sampling holes (3 inches across), and a sampling pole was used to collect the soil samples. (See Appendix C for more detail).

Deep Pole Planting and Caging: A mini-excavator with a stinger attachment was used to make 8 foot holes. Cottonwood saplings, harvested from a local nursery from stock originating on the Dolores River, were placed into the holes. Surrounding soil was shoveled and tamped into the holes. Caging was installed around cottonwoods with rebar to protect against herbivory and flagged for future monitoring purposes. (See Appendix D for more detail).

Cottonwood Harvesting/Transport/Storage: Cottonwoods harvested from the nursery were at least 8 feet tall, and pruned of all branches, save 2-5 at the top. Between harvesting and planting, cottonwood poles were stored with their bases in a bucket of water or the river. When transporting, a wet saturated cloth was wrapped around base of trees to provide constant moisture. (See Appendix E for details).

Installing Groundwater Monitoring Wells in Colorado: Monitoring permits were acquired by a four-step process through the Colorado Department of Water Resources. The assembled wells were comprised of two lengths of 5 foot galvanized steel casing plus a 3 foot long galvanized drive-point filter. The mini-excavator made an 8 foot hole and the well was inserted into the ground until groundwater was reached. Sandy soil was shoveled and tamped in around the well at least for the section around the filter at the base. Once the well was installed, a bailer was used to draw the water through the well filter to help move any fine sediments off of the filter and ensure good flow of water into the well. (See Appendix F for more detail).

Groundwater Monitoring Well: Data Collection Post-install: A Solinst 101 'e-tape' was used to measure the Total Depth (T.D) from top to bottom of well, the Depth-To-Water (D.T.W), and the Stick-Up (S.U.) of the well. Actual depth of groundwater was calculated by subtracting S.U. from D.T.W. Date and time were also recorded (tracking diurnal/seasonal variability of groundwater) (See Appendix G for details).

Mitigating Spread of Invasive Species: Between sites, persons, equipment, and vehicles were checked and cleaned of invasive plant species. (See Appendix H for more detail).

RESULTS

Deep Soil Sampling

The following section presents summary tables of the results for the Deep Soil Sampling effort.

Table 2: Deep Soil Sampling Summary of PLBE Site.

SITES	PLBE		
SOILS (Deep Sampling)	Avg	Min	Max
0-6" Soil Salinity (EC) mmhos/cm	0.41	0.25	0.61
0-6" Soil pH	7.92	7.50	8.00
Halfway Sample Depth (in)	41	36	48
Halfway Soil Salinity (EC) mmhos/cm	0.92	0.37	2.25
Halfway Soil pH	7.58	7.00	8.00
Bottom Sample Depth (in)	84	72	96
Bottom Soil Salinity (EC) mmhos/cm	0.82	0.59	1.31
Bottom Soil pH	7.67	7.00	8.50
PIT WATER	Avg	Min	Max
Water Table Depth (ft)	7.50	7	8
Pit Water Salinity (EC) mmhos/cm	0.94	0.72	1.09
Pit Water pH	7.00	7	7
Number of Trees Planted at This Site	20		
Number of Wells Installed at This Site	0		
RIVER WATER			
River Water Salinity (EC) mmhos/cm	0.59		
River Water pH	8.5		

Deep soil sampling and deep pole planting was conducted on the PLBE (Site A). The northern part of the property contained a layer of bedrock along the bank of the river, and thus obstructed efforts to find groundwater. On the southern end of the property, groundwater was reached along the bank of the river amongst willows. In this area, the soil and groundwater salinity was consistently below 4mmhos/cm (the threshold salinity for cottonwood viability). The salinity and pH of the river next to the sites was .59 mmhos/cm and 8.5, respectively. In total, twenty trees were planted on the site. No groundwater monitoring wells were installed.

Table 3: Deep Soil Sampling Summary of PLRO Sites.

SITES	PLRONI			PLRORO		
SOILS (Deep Sampling)	Avg	Min	Max	Avg	Min	Max
0-6" Soil Salinity (EC) mmhos/cm	1.00	0.40	2.43	1.12	0.33	2.21
0-6" Soil pH	8.00	7.50	9.00	7.64	7.00	8.00
Halfway Sample Depth (in)	41.00	32.00	47.00	33.57	30.00	36.00
Halfway Soil Salinity (EC) mmhos/cm	2.31	1.12	4.60	2.63	0.48	5.10
Halfway Soil pH	7.79	7.50	8.50	7.57	7.00	8.00
Bottom Sample Depth (in)	83.86	65.00	96.00	63.00	54.00	72.00
Bottom Soil Salinity (EC) mmhos/cm	3.21	1.41	5.12	3.64	0.76	4.67
Bottom Soil pH	7.64	7.00	8.50	7.31	7.00	8.00
PIT WATER	Avg	Min	Max	Avg	Min	Max
Water Table Depth (ft)	6.75	6	8	6.04	4.75	7.00
Pit Water Salinity (EC) mmhos/cm	6.843	2.35	16.24	7.42	1.67	20.00
Pit Water pH	7.313	7	8	7.00	6.50	7.50
Number of Trees Planted at This Site	5			7		
Number of Wells Installed at This Site	0			1		
RIVER WATER						
River Water Salinity (EC) mmhos/cm	1.13					
River Water pH	8					

Deep soil sampling was conducted at two sites on PLRO property. On PLRONI (Site C), five trees were planted and no groundwater wells were installed. The trees were planted along the bank. The salinity of the pit water ranged from 2.35-16.24 mmhos/cm, increasing upstream. On the PLRORO (Site B), seven trees were planted and one groundwater monitoring well was installed. The pit water salinity ranged from 1.67-20.00 mmhos/cm, increasing upstream. The two sites were located across the Dolores River from each other. The river water salinity was 1.13 mmhos/cm.

Table 4: Deep Soil Sampling Summary of the BLM Uncompahgre Field Office Sites.

SITES	Boatramp			BridgeTest						Hwy141Test1					
				1			2			1			2		
SOILS (Deep Sampling)	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
0-6" Soil Salinity (EC) mmhos/cm	0.48	0.33	1.54	0.82	0.11	1.60	0.71	0.25	1.30	0.35	0.12	0.65	0.30	0.21	0.39
0-6" Soil pH	8	7	8.5	7.93	7.50	8.00	8.00	8.00	8.00	8.13	8.00	8.50	7.75	7.50	8.00
Halfway Sample Depth	42	33	45	41.29	36.00	48.00	40.00	36.00	42.00	40.00	36.00	42.00	48.00	48.00	48.00
Halfway Soil Salinity (in)	1.46	0.42	10.57	2.25	0.89	3.78	1.58	0.48	3.45	0.45	0.27	0.73	1.56	0.90	2.21
Halfway Soil pH	7.5	7	8	7.64	7.50	8.00	7.70	7.50	8.00	8.13	8.00	8.50	7.50	7.00	8.00
Bottom Sample Depth (in)	84	60	94	82.57	66.00	94.00	84.00	84.00	84.00	82.50	72.00	90.00	96.00	96.00	96.00
Bottom Soil Salinity	2.56	0.83	4.27	1.35	0.52	2.40	0.69	0.53	0.86	1.17	0.44	2.82	0.36	0.36	0.36
Bottom Soil pH	7.5	7	8	7.93	7.50	8.50	7.50	7.00	8.00	7.88	7.50	8.50	8.00	8.00	8.00
PIT WATER	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Water Table Depth (ft)	7.75	6.5	7.75	26.54	7.50	75.00	7.40	7.00	7.50	7.80	7.50	8.00	8.00	8.00	8.00
Pit Water Salinity (EC) mmhos/cm	2.29	0.69	4.32	2.15	0.96	4.44	1.07	0.80	1.58	1.44	0.82	2.71	3.06	3.01	3.11
Pit Water pH	7	7	7.5	7.43	7.00	8.00	7.30	7.00	7.50	7.63	7.50	8.00	6.75	6.50	7.00
Number of Trees Planted	9			7			5			4			0		
Number of Wells Planted	2			1			1			0			0		
RIVER WATER															
River Water Salinity (EC) mmhos/cm	1.13			1.35						1.37					
River Water pH	8			8						8					

Deep soil sampling were conducted on five sites under the jurisdiction of the BLM Uncompahgre Field Office; Boatramp (Site D), BridgeTest1 (Site G), Bridgetest2 (Site H), Hwy141Test1 (Site I), and Hwy141Test2 (Site J). On Boatramp, nine trees were planted, and two monitoring wells were installed. Groundwater was reached close to the river bank and the groundwater salinity was between .69 and 4.32 mmhos/cm. Two wells were installed: One well was installed close to the river bank where the majority of the trees were planted while the second was installed upland.

At BridgeTest1 and BridgeTest2, a total of twelve trees were planted. Groundwater was reached close to the river bank at both sites. The salinity of the pit water ranged from .96-4.44 mmhos/cm and .80-1.58 mmhos/cm on BridgeTest1 and BridgeTest2, respectively. One well was installed at BridgeTest 2 close to the river bank, and one well was installed at BridgesTest1 upland from the river.

Hwy141Test was comprised of two subsites, Hwy141Test1 and Hwy141Test2. On Hwy141Test1, four trees were planted. The pit water soil salinity was between .82-2.71 mmhos/cm, conducive to planting trees. When groundwater was reached, it was located at the maximum depth of the stinger attachment, between 7.5- 8 feet. No trees were planted on Hwy141Test2. On the upstream portion of the site, the soil was inundated with water and appeared to be anaerobic throughout the entire eight foot depth. On the downstream portion of HwyTest2, the site was located on a high shelf, and no groundwater could be reached. No monitoring wells were installed on either site.

Table 5: Deep Soil Sampling Summary of PLPH sites.

SITES	PLPHPR			PLPHPO		
SOILS (Deep Sampling)	Avg	Min	Max	Avg	Min	Max
0-6" Soil Salinity (EC) mmhos/cm	0.57	0.55	0.58	0.87	0.50	1.43
0-6" Soil pH	7.75	7.50	8.00	7.88	7.50	8.00
Halfway Sample Depth (in)	33.00	30.00	36.00	36.00	24.00	48.00
Halfway Soil Salinity (EC) mmhos/cm	0.23	0.15	0.31	0.92	0.60	1.26
Halfway Soil pH	8.25	8.00	8.50	7.88	7.50	8.00
Bottom Sample Depth (in)	63.00	60.00	66.00	67.00	48.00	96.00
Bottom Soil Salinity (EC) mmhos/cm	0.35	0.24	0.45	1.50	0.32	3.12
Bottom Soil pH	8.00	8.00	8.00	7.50	7.00	8.00
PIT WATER	Avg	Min	Max	Avg	Min	Max
Water Table Depth (ft)	5.86	5.00	7.50	6.50	6.50	6.50
Pit Water Salinity (EC) mmhos/cm	0.68	0.46	0.82	13.35	6.70	20.00
Pit Water pH	7.57	7.50	8.00	6.50	6.50	6.50
Number of Trees Planted at This Site	16			0		
Number of Wells Installed at This Site	0			0		
RIVER WATER						
River Water Salinity (EC) mmhos/cm	1.08					
River Water pH	8					

Deep soil sampling was conducted in two general areas on the PLPH property, along the river site of PLPHPR (site E), and in a dried oxbow site PLPHPO (site F). Sixteen cottonwoods were planted along the river site. Along the river, the soil salinity ranged from 0.15-0.58 mmhos/cm, and the area's sandy soils were prime for cottonwood planting. No cottonwoods were planted in the dried oxbow. Groundwater was reached near preexisting cottonwoods which lined a section of the oxbow. In this area, the pit water salinity ranged from 6.7-20.0 mmhos/cm. The cottonwoods near the very saline water were experiencing rot and death. Areas in the oxbow away from these cottonwoods produced no groundwater. No groundwater monitoring wells were installed on PLPH property.

Table 6: Deep Soil Sampling Summary of PLBU sites

SITES	PLBU		
SOILS (Deep Sampling)	Avg	Min	Max
0-6" Soil Salinity (EC) mmhos/cm	0.94	0.55	1.81
0-6" Soil pH	8.00	8.00	8.00
Halfway Sample Depth (in)	31.60	28.00	36.00
Halfway Soil Salinity	1.96	0.76	3.08
Halfway Soil pH	7.80	7.50	8.00
Bottom Sample Depth (in)	63.00	52.00	72.00
Bottom Soil Salinity	2.02	1.18	2.92
Bottom Soil pH	7.40	7.00	8.00
PIT WATER	Avg	Min	Max
Water Table Depth (ft)	5.43	4.00	7.00
Pit Water Salinity (EC) mmhos/cm	1.56	0.65	3.34
Pit Water pH	7.61	7.00	8.00
Number of Trees Planted	9		
Number of Wells Planted	0		
RIVER WATER			
River Water Salinity (EC) mmhos/cm	1.23		
River Water pH	8.5		

Deep soil sampling was conducted in three general areas on the PLBU property. Of the combined three areas, the soil salinity ranged from 0.55-3.08 mmhos/cm, and the pit water salinity averaged 1.56 mmhos/cm. Nine cottonwood trees were planted on the property, and no groundwater monitoring wells were installed. In the area described as “PLBU2”, the cottonwoods will receive supplemental irrigation until they are more established.

Table 7: Deep Soil Sampling Summary of BLM Grand Junction Field Office sites.

Deep Sampling BLM Grand Junction Field Office Summary Table																					
SITES	**131arlPVT**			**PetDeep**			**CCBLM04**			**OP7**			**OP2**			**139bSouthRL**			**139aNorthRR**		
SOILS (Deep Sampling)	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
0-6" Soil Salinity (EC) mmhos/cm	0.51	0.20	0.98	0.31	0.10	0.79	0.84	0.75	0.93	0.53	0.19	1.37	1.37	0.53	2.79	1.52	1.52	1.52	1.41	0.10	4.43
0-6" Soil pH	8.58	8.50	9.00	8.63	8.00	9.00	8.00	8.00	8.00	8.45	8.00	9.00							7.88	7.50	8.50
Halfway Sample Depth (in)	33.33	17.00	48.00	27.70	18.00	42.00	38.50	38.00	39.00	33.36	24.00	42.00	18.00	15.00	24.00				37.07	28.00	45.00
Halfway Soil Salinity	1.52	0.55	2.37	1.84	0.12	21.00	7.63	4.33	10.92	1.36	0.37	4.55	1.60	1.04	1.88	1.1	1.1	1.1	2.51	0.48	4.68
Halfway Soil pH	8.33	8.00	9.00	8.68	7.50	9.50	8.00	8.00	8.00	8.09	7.50	9.00							7.54	7.00	8.00
Bottom Sample Depth (in)	65.67	36.00	96.00	54.80	40.00	78.00	80.00	78.00	82.00	70.59	48.00	88.00	35.00	3.00	48.00				74.43	48.00	90.00
Bottom Soil Salinity	1.72	0.46	2.53	1.45	0.14	5.09	1.81	1.05	2.56	2.71	0.54	5.47	3.46	2.02	4.70	1.4	1.4	1.4	2.80	0.77	5.44
Bottom Soil pH	8.67	8.50	9.00	8.48	7.50	9.50	8.00	8.00	8.00	7.62	7.00	8.50	7.25	7.00	7.50				7.29	6.50	8.00
PIT WATER	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Water Table Depth (ft)				5.98	5.20	6.75	7.38	7.00	7.75	5.98	4.00	7.40	3.74	2.25	5.50				6.55	5.50	8.25
Pit Water Salinity (EC) mmhos/cm		no water found		8.23	6.15	11.25	2.95	2.40	3.49	6.36	0.22	12.54	7.33	3.39	16.72		no water found		2.82	0.63	5.25
Pit Water pH				7.50	7.50	7.50	7.75	7.50	8.00	7.35	7.00	8.00	7.50	7.00	9.00				7.00	6.50	7.50
Number of Trees Planted	0			0			2			10			4			0			8		
Number of Wells Planted	0			0			0			1			0			0			0		
RIVER WATER																					
River Water Salinity (EC) mmhos/cm	1.33			2.51			1.33			1.27			1.5			1.46			1.32		
River Water pH	8.5			8.5			8.5			8.5			8			8.5			8.5		

Deep soil sampling was conducted on seven sites in the Grand Junction BLM field office; 131arlPVT (site L), PetDeep (site M), CCBLM04 (site N), OP7 (site O), OP2 (site P), 139bSOUTHRL (site Q), 13NorthRR (site R). On three sites—PetDeep , 139bSouthRL, 131aRLPVT—no groundwater was reached. Two trees were planted on CCBLM04. The low pit water salinity onsite was conducive to planting (2.40-3.29 mmhos/cm). On OP7, ten trees were planted and one groundwater monitoring well was installed. The pit water salinity ranged between .22- 12.54 mmhos/cm. Several trees were planted in holes with high salinity pit water because of uncertainty of planting procedure during training. High pit water salinity occurred on OP2, which ranged from 3.39- 16.72 mmhos/cm. Four trees were planted on the upstream portion of the site, in a region where preexisting cottonwood saplings were already established. On 139aNorthRR, eight trees were planted on the upstream portion of the site. Groundwater could not be reached downstream. When groundwater was reached, the pit water salinity ranged between 0.63-5.25 mmhos/cm. The mouth of Salt Creek was located at the upstream sites (131arlpVT and PetDeep), and may have been an influence on high average pit water salinity of OP7 and OP2.

Table 8: Deep Soil Sampling Summary of Rio Mesa Sites.

SITES	GROUPCAMP1			GROUPCAMP2		
SOILS (Deep Sampling)	Avg	Min	Max	Avg	Min	Max
0-6" Soil Salinity (EC) mmhos/cm	0.70	0.52	1.83	0.63	0.13	1.43
0-6" Soil pH	8.00	7.50	8.50	8.00	7.50	8.50
Halfway Sample Depth (in)	37.67	36.00	42.00	35.14	30.00	36.00
Halfway Soil Salinity (EC) mmhos/cm	1.35	0.53	2.87	1.49	0.56	2.93
Halfway Soil pH	7.67	7.50	8.50	7.71	7.50	8.00
Bottom Sample Depth (in)	72.00	60.00	84.00	68.57	66.00	72.00
Bottom Soil Salinity (EC) mmhos/cm	1.47	0.73	2.38	1.14	0.75	1.67
Bottom Soil pH	7.61	7.50	8.00	7.71	7.50	8.00
PIT WATER	Avg	Min	Max	Avg	Min	Max
Water Table Depth (ft)	6.52	5	7.5	6.36	6.00	7.00
Pit Water Salinity (EC) mmhos/cm	1.91	1.23	2.95	1.76	0.91	3.52
Pit Water pH	7.11	6.5	7.5	7.64	7.00	8.00
Number of Trees Planted at This Site	9			7		
Number of Wells Installed at This Site	1			1		
RIVER WATER						
River Water Salinity (EC) mmhos/cm	1.24					
River Water pH	8					

Deep soil sampling was conducted on two sites within the Rio Mesa property, Groupcamp1 (site S) and Groupcamp2 (site T). On Groupcamp1, nine trees were planted, while on Groupcamp2, seven trees were planted since the pit water and soil salinity on both sites were under the previously determined threshold. The average pit water salinity on Groupcamp1 and Groupcamp2 was 1.91 and 1.76 (mmhos/cm), respectively. One well was installed on each site.

Table 9: Deep Soil Sampling Summary of LABO Sites.

SITES	LABO		
SOILS (Deep Sampling)	Avg	Min	Max
0-6" Soil Salinity (EC) mmhos/cm	0.57	0.22	1.45
0-6" Soil pH	8.23	8.00	8.50
Halfway Sample Depth (in)	43.82	36.00	50.00
Halfway Soil Salinity (EC) mmhos/cm	1.64	0.73	3.14
Halfway Soil pH	8.18	8.00	8.50
Bottom Sample Depth (in)	86.18	70.00	96.00
Bottom Soil Salinity (EC) mmhos/cm	1.14	0.55	2.20
Bottom Soil pH	8.45	8.00	9.00
PIT WATER	Avg	Min	Max
Water Table Depth (ft)	No Water found		
Pit Water Salinity (EC) mmhos/cm			
Pit Water pH			
Number of Trees Planted at This Site	0		
Number of Wells Installed at This Site	0		
RIVER WATER			
River Water Salinity (EC) mmhos/cm	1.24		
River Water pH	8		

Deep soil sampling was conducted at LABO site (site U). The sampling took place upland from the river in shallow depressions. Despite the presence of nearby cottonwoods, groundwater was not reached in any of the five designated sampling areas. Because of the lack of groundwater presence, trees were not planted and wells were not installed on the LABO site. The average salinity of the surface and deep soil samples were .57 and 1.14 mmhos/cm, respectively.

Shallow Soil Sampling

The following section presents summary tables of the results for the Shallow Soil Sampling effort.

Table 10: Shallow Soil Sampling Summary of BLM Grand Junction Field Office Sites.

Shallow Sampling BLM Grand Junction Field Office Summary Table												
SITES	OP19			OP4			CCBLM01			PETWHIP		
SOILS (Shallow Sampling)	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
0-6" Soil Salinity (EC) mmhos/cm	0.15	0.15	0.15	0.33	0.13	0.64	0.31	0.31	0.31	0.36	0.15	0.58
0-6" Soil pH	8.50	8.50	8.50	7.75	7.00	8.00	8.00	8.00	8.00	7.55	7.00	8.00
6-12" Soil Salinity (EC) mmhos/cm	0.36	0.36	0.36	0.38	0.19	0.69	0.54	0.54	0.54	0.37	0.14	0.49
6-12" Soil pH	7.50	7.50	7.50	7.50	7.00	8.00	7.50	7.50	7.50	7.45	7.00	8.00
12-36" Soil Salinity (EC) mmhos/cm	0.49	0.49	0.49	0.55	0.25	1.53	0.66	0.66	0.66	0.46	0.13	0.97
12-36" Soil pH	7.50	7.50	7.50	7.35	7.00	8.00	7.50	7.50	7.50	7.10	7.00	7.50
PIT WATER	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Water Table Depth (ft)	2.20	2.20	2.20	2.00	2.00	2.00	no water reached.			2.75	2.75	2.75
Pit Water Salinity (EC) mmhos/cm	3.14	3.14	3.14	1.88	1.88	1.88				1.21	0.93	1.40
Pit Water pH	7.00	7.00	7.00	7.00	7.00	7.00				7.02	6.76	7.77
RIVER WATER												
River Water Salinity (EC) mmhos/cm	0.82			0.87			0.88			0.75		
River Water pH	8.00			8.00			8.00			8.00		

Shallow sampling was conducted at four river bank sites on Grand Junction BLM land. No plantings were conducted in any of the shallow sampling holes. The overall soil salinity (mmhos/cm) range of each site was as follows: OP19 0.15-0.49, OP4 0.13-1.53, CCBLM01 0.31-0.66, and PetWhip 0.13-0.97.

RECOMMENDATIONS

Equipment:

MapitFast/Strider Software and Samsung Tablet

During the 2014 Cottonwood Sustainability Assessment Project, the MapitFast program was used in conjunction with Strider software (both from company AgTerra) were installed. These were installed on a Samsung tablet (we used a Samsung Galaxy Tab 2 with 10.1 inch screen) and utilized to collect data more efficiently in the field. MapitFast acted as a GPS unit, map, camera, and provided data forms, effectively streamlining the data collection process. MapItFast data could be loaded onto the MapitFast cloud when cell service was available, thus reducing the time and effort needed to transfer the data manually. The tablet had good battery life that would last the full ten hours in the field, but extra batteries and multiple chargers (e.g. car charger, solar charger) were carried in the field.

It is recommended that several steps occur prior to utilizing these in the field with crews: (a) spend time developing and field testing your Strider data collection form to streamline it, (b) plan adequate time for training field crews to utilize equipment, (c) spend adequate time practicing data collection in the field WITH the crews to ensure that everyone is on the same page, (d) develop a clear plan for regular backups of data (daily backup is highly recommended) to ensure minimal problems if data is lost, and (e) always carry paper datasheets as backup in case you experience technical difficulties in the field (e.g. dead batteries).

Because of the remote nature of our project (e.g. working on many sites where cell phone reception/data connections were not possible), it was necessary to pre-load the basemaps and layersets onto the Samsung tablet in the office. It is absolutely CRITICAL that prior to the field season, these basemaps are tested at all of the zoom levels needed to ensure workability, because the process can be time consuming and complex to navigate. It is also highly recommended that paper map copies be carried as a back up.

The Strider program can be used to streamline report building, but for our purposes we found it easier just to download the data into ArcGIS and Microsoft Excel for this project.

Hanna pH/ salinity meter

The Hanna pH/salinity meter used in the field was the HI98130. This meter was tested prior to fieldwork against a more advanced Hanna pH/salinity meter and was found to be quite accurate (assuming regular calibration of the field meter). The HI98130 was lightweight and had a stellar battery life. The meter should be calibrated every few days for maximum accuracy. The meter is dark in color so it is highly recommended that it is kept in a bright case or otherwise flagged with a bright color so that it isn’t lost in the field.

Sampling Pole

The sampling pole consisted of a 10 foot stainless steel pole with a metal cup welded onto the end. The cup on the pole was used to collect both pit water samples and soil samples for deep soil sampling. A paint pen marked 6 inch increments along the pole. While two poles were created, the sampling pole with the larger metal cup (2 inch height) was preferred.

Stinger Attachment

The Kubota mini excavator with an 8 foot x 3 inch stinger attachment was used to make holes for deep soil sampling, deep pole planting, and well installation. The hole depth was limited by the length of the stinger. In some sites, groundwater was found to be more than eight feet below surface. Although mobility might be compromised, a longer stinger may be able to locate groundwater at depths presently unavailable with current attachment.

Mobilization:

Excavator and Trailer

Roads should be pre-assessed for safe accessibility of excavator and trailer. Ground conditions of site should be considered as soft ground or steep banks are not accessible for excavator. Land owners/managers should be consulted prior to activity to determine if the use of an excavator (or other heavy machinery) will cause an unacceptable level of disturbance on the property.

River Crossings

Several project sites involved crossing the Dolores River. Plan potential crossing sites for persons and machine. Scout places for the excavator to cross. The water level at these river crossings cannot exceed the height of the machine's tracks. For persons, decide based on available equipment and the current river condition whether the use of waders or a canoe is appropriate. Make sure that use of proper flotation devices and safe crossing practices are adhered to.

Weather:

Weather during the project was variable, as the project spanned from early February to late March. Plan accordingly. Electronic equipment was weatherproofed in an Otter box (shockproof and water resistant case). Shallow sampling was done later in the season when the ground was more likely to be thawed. During the thaw period, rubber boots were very helpful. After heavy rains, some sites may become inaccessible to the excavator. Assess the site conditions accordingly.

Well Permitting:

Well permitting is a four-step process in Colorado. Plan a significant amount of lead time for submitting the necessary paperwork in advance of the project start date. For more information about the process, see Appendix F.

APPENDIX A

Data Collection Electronically: Using MapitFast/Strider Software

Note: The following presents a list of instructions that worked for our particular situation and our particular Samsung tablet (Samsung Galaxy Tab 2, 10.1 inch screen, with an inserted additional SD memory card). Directions may vary for other tablets and later versions of MapitFast/Strider.

Troubleshooting Tips for MapitFast on Samsung tablet

- When all else fails, exit MapitFast, and reload program. If MapitFast still is not working, try rebooting the tablet.
- Pre-load basemaps with WIFI connection before going into the field.
- To view a base map, the map may have to be at a specific zoom level. Desired zoom levels should be determined before the project begins, in the office, based on project and navigation needs.
- Zooming too far into the basemap may cause a blank screen with a horizontal line to appear. Exit out of MapItFast to regain the original screen image.

Directions for loading aerials in Map-It-fast

1. Select “Settings” icon at the top
2. Select “Settings”
3. Select “Select Basemaps” button
4. Push “Manage Custom Basemaps” button
5. Delete existing map if one is there and push “yes” when asked about deleting
6. Push “add custom basemap” button
7. “Browse…” to “extSdcard/”
    a. Under “Location:/” scroll down until you find the “extSdCard/” and select it
8. Scroll to appropriate file for your site and select it
9. Push “OK” button when file is added to list (if wrong file is added, you must reselect the file in the list of files to remove it, and then select the correct file).

    DO NOT LOAD MORE THAN ONE FILE AT A TIME OR NONE WILL DISPLAY

10. Push “Done” button
11. Add a name for your basemap and leave other fields empty

12. Push “Save” button
    - Note: You can repeat this process and add all basemaps if you wish, but only one at a time may be selected, and only one at a time will show on your display
    - To exit Custom Basemaps screen you must back out using the regular tablet icons
    - For some reason the selected image will not appear the first time selected, so push the “select” button, then go back through steps 2-4 above
    - Select “custom” and then the desired basemap file from the dropdown menu and push “select” button

Troubleshooting the MapItFast Online Cloud

When loading the collected data for each project onto MapItFast online cloud, be sure to load the project on the tablet screen beforehand. If the project won’t load, exit out of MapItFast on the tablet, and reload the page. If project is loaded onto the cloud, the points should be on the cloud as well. When selected, the map on the screen will zoom to the specific project with the collected data points. If the points are absent, just wait. Often, the project takes time to load completely onto the cloud. DO NOT DELETE THE PROJECT OFF OF THE CLOUD. YOU WILL NOT BE ABLE TO RELOAD IT FROM THE TABLET ONTO THE CLOUD AGAIN. The project will be erased completely off the server.

Troubleshooting Strider

- If projects are on the cloud, but the forms are not available on Strider, they may need to be reopened in the tablet and allowed further time to synchronize.
- To tell if a point has been ‘Synchronized’ onto the cloud:
    - ‘Settings’
    - ‘Sync Settings’
    - Make sure the ‘Show Advanced Sync Info’ button is enabled and ‘Save’
    - Click on any point
    - At the bottom of the point’s information, under the date, it will say “Not Synchronized” or “Synchronized”
    - Once points have been synchronized, all their information will be available on the online cloud, as well as on Strider forms

APPENDIX B

Shallow Sampling

Materials:

- Shovel/Spade
- Trowel
- Gloves
- Measuring Tape
- Distilled water
- pH and salinity meter (used Hanna Meter HI98130) + calibrating solutions
- Bucket
- Cup for mixing
- Mixing Stick
- Measuring cup
- Data collection tablet (*we used Samsung Galaxy Tab 2, 10.1 inch screen, loaded with MapitFast/Strider software*) or other type of data collection sheets

Procedure:

1. Dig a three foot deep hole on the river bank.
2. Use latex gloves to test the soil.
3. From 0-6 inches, using the trowel, scrape off the exposed soil surface to uncover intact soil layers for testing.
4. With the newly exposed soil, start at the top and scrape a thin even layer down to 6 inches.
5. Transfer soil to bucket, and thoroughly mix the soil until different layers are evenly distributed.
6. Use part of the sample to perform a soil texture test (See Texture Flow Chart).
7. Put the remaining sample into the mixing cup and add distilled water for a 1:1 ratio.
8. Mix until the soil and water mixture is of paste consistency.
9. Use the pH and salinity meter to test the paste mixture.
10. Repeat steps 3-9 for 6-12 inches and 12-36 inches soil samples.
11. If water is reached, test the salinity and pH.
12. Fill hole when finished.

Recommendations:

- In order to keep soil samples uncontaminated, clean spade and buckets between each use, and change gloves for each sample.
- If it is not possible to reach 36 inches when digging a hole, be sure to record the depth reached.

APPENDIX C

Deep Sampling

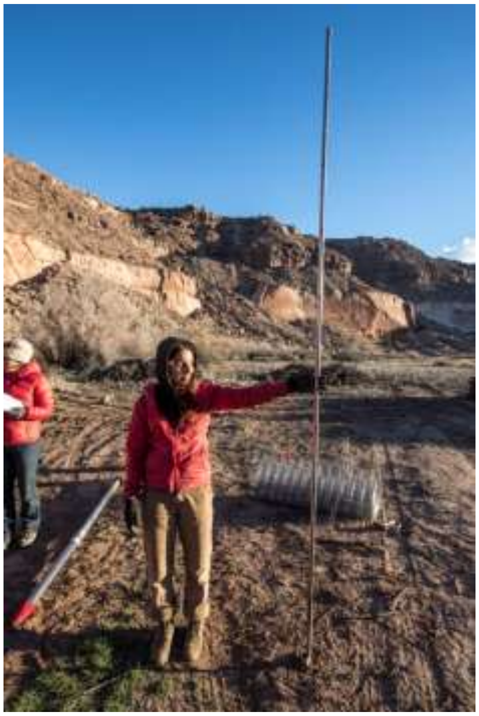
Materials:

- Heavy machinery with 8-12 foot stinger attachment (used Kubota mini-excavator)
- Sampling pole with measurements and small sampling cup attached at bottom
- Cup for testing
- Measuring cups
- Mixing stick
- Distilled water
- pH and salinity meter (used Hanna Meter HI98130) + calibrating solutions
- Data collection tablet (*we used Samsung Galaxy Tab 2, 10.1 inch screen, loaded with MapitFast/Strider software*) or other type of data collection sheets

Procedure:

1. With the heavy machinery and stinger attachment, make deep sampling hole until reach significant ground water (depth of hole dependent on depth to water table and length of soil drilling attachment).

2. Measure the depth to groundwater (if water is reached) with pre-measured sampling pole.



3. Retrieve ground water (pit) sample with sampling pole cup and transfer to testing cup.

4. Using the pH/salinity meter, test the pit water.

5. Rinse the cup and meter with distilled water to prepare for next level of testing.
6. If the bottom of the hole is inundated, but not watery enough to test straight (e.g. 'sludge'), sample the bottom contents using a 2:1 ratio (sludge sample: DI water) with distilled water.
7. Take bottom depth sample just above the pit water depth, by scraping the soil off the wall of the hole with the sampling cup, and noting the depth.
8. Use this first sample for a texture test (see texture Flow Chart).
9. Repeat step 7 for pH/salinity test at same depth.
10. Measure a small amount of soil, transfer to mixing cup, and add distilled water for a 1:1 ratio with soil.

11. Mix contents until a paste consistency is reached.
12. Test paste mixture for pH and salinity.
13. Rinse mixing cup and testing meter between each use.
14. Repeat steps 7-11 for a soil sample at halfway depth and a soil sample at the top between 0-6 inches.
15. Fill hole when finished, unless it will be used for a deep pole planting.

Recommendations:

- The pit water is not always pure water. If it is of soupy consistency, it is okay to test straight. However, if it is sludge, it is important to add only enough water to create a paste-like mixture; this is usually 2 parts sludge to 1 part distilled water.

APPENDIX D

Deep Pole Planting and Caging

Materials:

- Heavy machinery with 8-12 foot stinger attachment
- Tamping device
- Shovel
- Pruned 2-year-old cottonwood pole
- 5 feet of 4 foot tall 14 gauge welded wire fencing with 2 inch x 4 inch spaces (purchased at Home Depot)
- 2 pieces of 3 foot long, 3/8 inch rebar (but could use other lengths)
- Single jack hammer or similar type hammer
- Wire cutters
- Flagging
- Gloves
- Pliers

Procedure:

1. With the heavy machinery and stinger attachment, make deep sampling hole until reach significant ground water (depth of hole dependent on depth to water table and length of soil drilling attachment).
2. If hole is suitable for cottonwood planting (see recommendations for planting cottonwood), place cottonwood pole into the hole and push it as far down as possible.

3. Using shovel, fill in hole around the cottonwood pole while simultaneously tamping the soil down.
4. Leave a shallow depression around the cottonwood for water to collect during rain events.
5. Cut five feet of wire caging from four foot tall roll. Cut cage so that the wires on one end are free to wrap around the wire on other end.
6. With pliers, bend the cut side around the intact side to encircle the newly planted cottonwood pole with caging, leaving a minimum of a one foot radius buffer around the entire pole (we used a great caging reference = *Beaver: Best Management Practices,* a Grand Canyon Trust publication)
7. Weave the three foot rebar in between the squares of the wire caging for stability and use single jack hammer to pound the rebar at least a foot and a half into the ground. Do the same with the second piece of rebar directly across from the first piece.
8. Place flagging on the cage so it is noticeable and can easily be found again when you come back to check it out.

Recommendations for Planting Cottonwoods:

- Deep pole plant cottonwoods during the early spring before the leaves bud out, allowing the roots to establish.
- Plant cottonwoods in holes with:
    - Presence of groundwater,
    - Soil and water salinity <4 mmhos/cm*,
    - Two feet of dry soil above water level, and
    - Aerobic soil (at least the absence of obviously anaerobic soil)
- If the base of the cottonwood is cracked or appears dry, it may be snipped or lopped off to expose fresh plant material before installing into hole

Recommendations for Caging Cottonwoods:

- Use protective gloves, especially when caging.
- If the ground is sandy or sloped, use extra rebar for support.

**We used this cutoff for salinity based on the book Sher et al. 2010. Best Management Practices for Revegetation after Tamarisk Removal In the Upper Colorado River Basin. Denver Botanic Gardens, Denver, CO. In this booklet it states that the maximum salinity that cottonwoods can tolerate is 4 mmhos/cm.*

APPENDIX E

Cottonwood Harvesting/Transport/Storage

Recommendations on Harvesting Cottonwood Poles:

- Cottonwood poles should be at least 8 feet long, depending on how deep you anticipate your hole will be. We typically had at least 3-5 feet of pole sticking out of our drill holes, which were a maximum of 8 feet deep.
- Prune cottonwood poles, leaving only about 2-4 branches at the top. This allows the cottonwood to channel energy to root establishment, rather than leafing out.
- When pruning cottonwood pole, cut limb at 0.5-1 inches out from the trunk.
- Remember that pole width at the base needs to be SMALLER than the width of the stinger or other hole drilling implement, SO PLAN ACCORDINGLY!!!

Recommendations for Transporting Cottonwoods:

- To retain moisture when transporting, keep the base of cottonwood poles wrapped in a soaked cloth (e.g. burlap sack)
- Be sure cottonwoods are horizontally secured during transportation.

Recommendations for Storage:

- Cottonwood poles must be kept moist with bottoms either in a bucket of water, or along the bank of a river. If putting poles in river make sure they are secured so they don't float away.
- Note: Do not leave trees in river overnight as beavers have been known to steal them!
- Once the cottonwood pole begins to leaf out, if it has not been planted, its chances of viability decrease.

APPENDIX F

Installing Groundwater Monitoring Wells in Colorado

Overview of What you need to know:

- Type and size of well material desired
- Maximum depth.
- Exact location for installation (Township/Range (1/4,1/4 section) and GPS coordinates) Site selection will be up to the land owner, the land manager, the desired reason for monitoring, and local conditions…
- Installation Methods
- Permitting process and regulations
- Who will be responsible for installation (must be a hydrologist or certified well driller)
- Associated Installation Materials (see list below)

Step by Step

STEP 1 PERMITTING

1. Online, go to Colorado Department of Water Resources: http://water.state.co.us

Under “Groundwater” tab, see “Well Permitting”. There is a lot of information available here. Scroll to bottom of page and click on “Monitoring and Observation Well” (permanent or temporary-depending on your intentions). This is everything you need to know and more…

2. Gather information: Well Owner name and address, Landowner name and address (if different).
3. Determine who will be responsible for the well installation. This must be an agency hydrologist or a certified well driller, Professional Engineer in CO, or Geologist. This is who will sign off on the well.
4. Determine which Aquifer the well will be located in.
5. Determine where to get the materials needed. There are many choices. You can buy or build your own simple monitoring piezometer with PVC/metal and a hacksaw or Sawzall. This document will not go into how to make and install your own. You can purchase more sophisticated (and expensive) metal well materials that will be more permanent. We used Dean Bennett Supply – they were responsive and shipped quickly. The monitoring wells we installed were comprised of (a) a Drive Point (including a filter or screen), (b) Lengths of galvanized, threaded steel pipe/couplers, and (c) a Drive Cap. Note that if installation by hand (e.g. post pounder or sledge hammer) or machine is the plan, then a Heavy Duty Cast Iron Drive Cap is recommended. This will allow for installation without stripping threads or damaging the cap.
6. **FORM #1 of 4** = Use the above information and Township and Range and GPS location information to complete **Form GWS-51 “Notice of Intent to Construct Monitoring Hole(s)** at least three days before proposed well construction (but give yourself a couple weeks if you can). This can be done online from the link above. The NOI is the first of four forms that must be completed throughout the process. The NOI should be approved within one week of submission (and can be as soon as 2 days).
7. **FORM #2 of 4** = For non-standard wells (see Rule 6, Rule 9, Rule 10 and Rule 18 in the Water Well Construction Rules available at the above site), a **“Variance Request” (Form 1- found at the above website)** must also be submitted once the NOI (GWS-51) is approved. NOTE: the accepted NOI will be returned to the person/entity signing off on the NOI, however anyone can check the status of the NOI online by clicking on “well permit search” in the DRW website and filtering per the choices allowed (The best success occurred when searching by county or permit number). Response on the Variance should be within 2 days to a week, searchable in the same manner described above, or by contacting the person signing off on the NOI. (You may have success requesting to be cc’d on responses from DWR as well).
8. YOU NOW HAVE THE GREEN LIGHT TO INSTALL YOUR WELL! But there is still more paperwork to complete- see below installation section. Make sure you have the materials you need and have coordinated installation with the hydrologist (or engineer or geologist), the land owner/manager, and determined access for personnel and equipment.

STEP 2: How to install a groundwater monitoring well

Depending on the size, depth, and type of well you have chosen, there are a number of ways to install it.

EQUIPMENT NOTE: you will need at least 2 large pipe wrenches or Channel locks to tightly thread the well components.

> **Option A** = Hand pound into soft soils (not highly recommended). The Heavy Duty Drive Cap can be threaded first to the Drive Point and either sledge hammered or post pounded into the ground. More sections can be coupled as you get deeper. This is hard. NOTE: Heavy Duty Drive Caps are wider than typical post pounders so you may need to get a special one welded if this is your choice. Be sure to have the appropriate Personal Protection Equipment (PPE) on hand.
>
> **Option B** = Use an auger to bore out your hole (recommended). There are lots of different choices here from hand augers, to gas powered augers on tripods to machine mounted. Augers typically have a rough time in cobble. You can get to groundwater and assure you have contact (recommended). The width of the auger needed will relate to your well diameter. You will need an auger long enough to get down into the groundwater or have to finish by hand.
>
> Use heavy equipment such as a skid steer or excavator with a "Stinger" to poke into the soils. Ideally your stinger is the width of the well you are proposing to install and a length appropriate for your conditions. A mini excavator with a long reach and an 8 foot 2 inch wide stinger can work well. This is by-far the easiest way to install a well. If the operator pokes a hole and assures there is groundwater, the hole can be "bored" out a bit to allow easier well installation, the well threaded together and physically pushed into the ground by the machine. Ideally, the well can be sunk beyond the bottom of the stinger hole. This can be monitored by knowing the lengths of the various components compared to the depth of the stinger (or auger). Make sure the threads are as tight as possible and the machine pushes the well down straight or you may break something. Stand back and use proper PPE!

No matter what installation method you choose, it is important to have a monitoring well that sticks up at least 1 foot above the ground in case of flooding- to reduce surface inundation. However, local conditions, user groups, future activities, and land use may dictate a different approach.

Recommendations

- If at all possible, backfill your well hole (at least to approximately 1 foot above the height of the filtered drive point) with sandy soil to help filter incoming water and minimize fine sediments building up on your filter. You can then fill the rest of the hole with regular soil from the surrounding area.
- Ideally have a well installed at a depth where you can maximize groundwater infiltration into the well. In a perfect world 2-3 feet of water in your hole to start would be great. This may not be possible at all locations- in this situation, make sure to get the drive point deeper than the hole depth.

Associated Equipment

Besides the tools and equipment mentioned above, you may need a few other things to establish a good monitoring well and test water depth.

A Bailer is an instrument that can be inserted in a well to remove the first bit of dirty water and "purge" the filter that may have become soiled or clogged during installation. The bailer should be used to remove water from the well until the well is dry or the water is clear (emptying 20 bailers could be a good placeholder).

In the absence of a bailer a weight such as a large nut could be tied to a string and the screen could be purged in this manner by plunging it into the well.

To test the depth to groundwater (and the depth of the well) a tape measure can be used but is difficult to tell when the tip contacts the water. If you know the total size of the well casing you can measure the section above ground to subtract from the total to determine well depth. A water level meter (also known as an E tape) is a convenient piece of equipment that can be lowered into a well and senses when in contact with water.

Follow up paperwork with DWR

- **FORM #3 of 4** = **Well Construction and Test Report:**

  Once your well is installed you will need to submit a Well Construction and Test Report (Form GWS-31) within 60 days of installation. Note- you will need to include the well permit number (from the returned NOI), the well owner information, the well location as-drilled, the elevation of the well and the Distances from Section lines, the total depth, completion date, grain size, type and water location, plus hole diameter and casing size used. Plan ahead to assure you collect this information during construction!

- **FORM #4 of 4 (two options)**

  - **Monitoring/Observation Well Permit Application:**

    If you plan to use your well beyond one year of installation, you must complete form GWS-46 to receive an official permit. This includes a fee of $100.00 and summarizes some of the information from previous paperwork submitted.

  - **Well Abandonment Report:**

    If you do not intend to continue to use the monitoring well past one year of construction, the well must be plugged and for GWS-09 must be filed within 60 days of abandoning the hole.

APPENDIX G

Well Data Collection Post-install

Materials

- E-Tape (we used a Solinst 101)
- Data collection sheet

Procedure:

1. Turn E-Tape dial on and press battery test button to test battery power and volume.
2. Lower the E-Tape down into the well until the E-tape sounds.
3. Record the Depth to Water (D.T.W) in hundredths of a foot.
4. Record the Stick Up (SU) height
5. Subtract Stick Up height (height of the well up from the ground) from D.T.W to calculate the groundwater level.
6. To measure Total Depth (T.D) of well, turn off audible sound and lower the E-Tape down to bottom of the well until you feel it touch the bottom and record full length shown on tape.
7. Record the date and time of data collection, and name of data collector. The groundwater level will exhibit diurnal fluctuations, especially during the spring snow run off.

Recommendations

- Attempt to take the well monitor measurements at the same time of day because of the diurnal fluctuations of the groundwater level.
- It is helpful to have one place to record all the well data (e.g. have all data associated with given well in a single spreadsheet)
- Total Depth (TD) may vary slightly because of sediment build-up at the bottom of the well. Therefore, it is worthwhile to measure it regularly.

APPENDIX H

Mitigating Spread of Invasive Species

Nonnative species can be spread very easily via human activity. It is our responsibility to take measures to mitigate the spread of nonnative species. The following are things to screen for nonnative plants when transitioning from site to site:

- Sampling Equipment (such as sampling jar protector above)
- Shoes, clothing, and self
- All Vehicles including contractors, crew members, consultants, other visitors (i.e. tire tread, undercarriage)
- All Heavy Equipment (e.g. Excavator)

Materials Used for Cleaning Heavy Equipment

- Rockbar
- Portable pressure washer
- Broom
- Other suggestions – sometimes a gaspowered leaf blower can be useful to blow seeds and other invasive plant material out of machine

Method Used for Cleaning Heavy Equipment

- At a minimum, we fully cleaned the heavy equipment between each landowner
- Typically, if there were multiple sites for one landowner, we would ask the landowner how they wanted us to clean between each site (since we were working in remote locations with limited access to water and on a short time frame)
- One land manager had us work on the 'cleanest' sites first and then move our equipment on to the sites with more weeds, so we didn't need to clean in between sites for that landowner
- Another land manager felt that all of their sites had a similar composition and amount of weed species, and did not feel it was necessary to clean the machine between sites or order the visitation of certain sites