

# Biochar 2011 Data Summary: Figures and Tables

Figure 1. Biochar publications (A) and publications addressing mine lands remediation (B).....	5
Figure 2. Generalized geology of the Upper Animas basin. ....	5
Figure 3. Topography in the Upper Animas Basin. ....	5
Figure 4. Generalized map of alteration types in the Upper Animas, From Yager et al 2008. ....	6
Figure 5. San Juan volcanic field (Colorado Geological Society). ....	6
Figure 6. Pleistocene glacial extent at maximum phase ~18,000 YBP (Skinner and Porter, 1987).....	7
Figure 7. Mean and 95% confidence interval for monthly precipitation (blue) and mean temperature (dashed) for Silverton (from Western Regional Climate Center – WRCC, 3/1/1899 – 10/31/2011). ....	7
Figure 8. Average snow depth (grey) and precipitation by month (blue) from WRCC (3/ 1/1899 to 10/31/2011).....	8
Figure 9. Average snow depth (grey) from WRCC (3/ 1/1899 to 10/31/2011) and stream flow (blue) in the Animas below Silverton, CO, USGS stream gage 09359020.....	8
Figure 10. Biochar tests sites in the Upper Animas Basin. ....	9
Figure 11. Bonner site map. ....	10
Figure 12. Bonner site map. ....	10
Figure 13. Bonner 5 X 5 meter plots (a – 30%) (b – 15%). ....	11
Figure 14. Biochar flume at Bonner draining adit. ....	11
Figure 15. Joe John repository site.....	12
Figure 16. Joe & John repository quadrants and rates indicated in red (% in yellow).....	13
Figure 17. Lackawanna mill site .....	13
Figure 18. Site map of the Lackawanna Mill. ....	14
Figure 19. Highland Mary site map. ....	14
Figure 20. Plot location at Highland Mary site. ....	15
Figure 21. Little Molas Campground (June 2010). ....	15
Figure 22. Brooklyn site with plots on the lower level. ....	16
Figure 23. Brooklyn site map. ....	16
Figure 24. Red and Bonita Site. ....	17
Figure 25. Red and Bonita site image from north of pile. ....	17
Figure 26. Road Cut soil collection site. ....	18
Figure 27. Across from Bonner site map.....	18
Figure 28. Eveline Site Map.....	19
Figure 29. Column experiment at the Eveline Mine.....	19
Figure 30. Boston Mine Site.....	20
Figure 31. BSI BET surface area (m <sup>2</sup> ) and fixed carbon (%). ....	21
Figure 32. Biochar Engineering mobile biochar production unit.....	22
Figure 33: BSI Base Unit, conveyor dryer and oxidizer December 2011, Pueblo Colorado. ....	23
Figure 34. Colorado Biochar LLC, field pyrolysis unit. ....	23
Figure 35. Example layout and plot installation at the Highland Mary site.....	24
Figure 36. Column configuration for Eveline ZI - biochar treatment volumes. ....	24
Figure 37. Eveline AMD water treatment columns. ....	24
Figure 38. Eveline mine draining adit (A) and treatment columns (B). ....	24
Figure 39. Greenhouse trials 1-6-2012.....	25
Figure 40. Greenhouse trials January 31, 2011. ....	25

Peltz 2012. Biochar Data Summary 2011

Figure 41. Greenhouse experiments March 6, 2012. .... 25

Figure 42. Biochar additions for 2012 greenhouse experiments in lbs./Meter and lbs./Acre. .... 26

Figure 43. Biochar application at the Joe John site. .... 26

Figure 44. Incorporating biochar at Joe John site. .... 26

Figure 45. Vegetation cover (%) for all field plots in 2010 and 2011, dashed line indicates mean. .... 27

Figure 46. 2010 (A) and 2011 (B) vegetation cover in biochar treatment plots, dashed lines indicate mean. Bio30 – 30% biochar volume, BioMulch – 30% biochar + straw mulch, NCTL – No seed control , Mulch – Straw Mulch, SCTL – Seed only control (50g/m<sup>2</sup>). .... 27

Figure 47. Vegetation cover (%) by treatment and year. .... 28

Figure 48. Total cover in 2010 and 2011 for Bonner, Highland Mary, and Little Molas Camp. .... 28

Figure 49. 2010 (A) 2011 (B) field cover for biochar test plots at Acid (Bonner, Joe John, Lackawanna) and Non-Acid (Highland Mary, Little Molas) sites. .... 29

Figure 50. 2010 (A) 2011 (B) field cover for biochar test plots at Mine (Bonner, Joe John, Lackawanna, Highland Mary) and Non-Mine (Little Molas) sites. .... 29

Figure 51. Above ground biomass (g) for biochar (n - , ) and non-biochar (n - , ) and by treatment for 2010 container trials. .... 30

Figure 52. Above ground biomass for acid and non-acid (A) and mining and non-mining (B) affected sites. .... 30

Figure 53. Greenhouse/container trials 2010. .... 31

Figure 54. Containers at 40 days with soils from Highland Mary (mining, non-acid site). .... 31

Figure 55. Containers at 40 days with soils from Bonner (mining, acid site). .... 31

Figure 56. Range of height values by treatment for 2012 greenhouse trials, dashed lines indicate mean. .... 32

Figure 57. Height of green vegetation (mm) measured in 2012 container trials at weekly intervals, bars are values at each time step, lines indicate 2<sup>nd</sup> order polynomial regression fit to height data. .... 32

Figure 58. Soil volumetric water content. .... 33

Figure 59. 2010 (A) and 2011 (B) field VWC (%) for biochar and non-biochar amended plots, dashed lines indicate mean, and differences in VWC are significant at p < 0.001. .... 33

Figure 60. Volumetric water content (%) for Bonner and Joe John sites in 2010 and 2011. .... 34

Figure 61. Volumetric water content (%) for Highland Mary and Little Molas Campground in 2010 and 2011. .... 34

Figure 62. Volumetric water content (%) for container trials by biochar vs. non-biochar (A), and by treatment (B). .... 35

Figure 63. 2010 container VWC (%) by acid sites (A) and by mining affected sites (B). .... 35

Figure 64. Soil VWC through time for combined biochar treatments. .... 36

Figure 65. Soil VWC measured at 7 day intervals at the Bonner and Highland Mary site 2011 .... 36

Figure 66. Soil leachate chemistry for Bonner 2010 (A – As, B - Mn, C – Zn, D – Fe). .... 37

Figure 67. Average concentration (mg/L) for soil leachate for the Joe John Site - 2010 (A – As, B – Mg, C – Zn, D – Fe) Y axis are dates in 2010. .... 37

Figure 68. Soil leachate from a 30% biochar treatment (A) and soil only control (B)...**Error! Bookmark not defined.**

Figure 69. Aluminum, AMDS-Inflow values from Ford, Fleming and Odell (2009), values in parentheses represent % decrease from the Evelyn-Inflow values. .... 38

Figure 70. Cadmium, concentrations in effluent waters, biochar columns, and standard for Cement Creek (green). .... 38

Figure 71. Total copper concentrations in effluent waters, biochar columns, and standard for Cement Creek (green). .... 39

Figure 72. Iron concentrations and Evelyn outflow and biochar columns. .... 39

Figure 73. Manganese concentrations in effluent waters. .... 39



Peltz 2012. Biochar Data Summary 2011

Figure 74. Sulfur concentrations in effluent waters and biochar columns..... 40

Figure 75. Total Zinc concentrations in treatment biochar columns, and Cement Creek standard (green).  
..... 40

Figure 76. Mass of analytes removed after passing through biochar and ZI treatment media. .... 41

Figure 77. Mass removed of selected analytes after passing through treatment media. .... 41

Figure 78. Formation of iron ferricrete from AMD water. .... 42

Figure 79. Mean carbon content of the first six inches of soil, bars 1 SEM. .... 42

Figure 80. Predicted carbon volumes (%) at the Joe John site using a spline fit interpolation technique. 43

Figure 81. Predicted carbon volumes (%) at the Joe John site using an inverses distance weighting  
technique..... 43

Figure 82. Predicted carbon volumes (%) at the Joe John site using an ordinary krigging technique. .... 44

Figure 83. Soil pH of collected samples..... 44

Figure 84. Interpolated soil pH by spline (A) and inverse distance weighting (B). .... 45

Figure 85. Relationship of measured soil carbon and soil pH. .... 45

Figure 86. USGS laboratory set-up for soil column experiments. .... 46

Figure 87. USGS column preparation. .... 46

Figure 88. Laboratory design for Doug Winter AMD Treatment Cells..... 47

Table 1. Climate statistics for Silverton, CO (1907-2005)..... 48

Table 2. Biochar Study Sites in the Upper Animas Basin ..... 48

Table 3. Seed type and rate applied for 2010 field and container trials. .... 48

Table 4. Seed mix used in 2011 field and container trials. .... 48

Table 5. Biochar calculation estimates for the Joe John Site..... 49

Table 6. Soil Chemistry (ppm) at the Brooklyn site measured by X-Ray Reflectance in 2009 ..... 49

Table 7. Eveline draining adit water chemistry (mg/L) 2011..... 49

Table 8. Eveline water chemistry as measured by Ford, Fleming, and Odell (2007) ..... 49

Table 9. Biochar production values - from BSI ..... 49

Table 10. Soil amendment sites and actions taken in 2011. .... 49

Table 11. Average soil leachate concentration (ppm)..... 50

Table 12. Average soil leachate pH for biochar treatments at multiple intervals. .... 50

Table 13. One way ANOVA for field VWC (%) by biochar and non-biochar treatments..... 51

Table 14. One way ANOVA table for field VWC (%) in 2010 and 2011 by treatment. .... 51

Table 15. Least square means for field VWC (%) by year and treatment (SEM - standard error of mean).  
..... 51

Table 16. One way ANOVA for VWC (%) in 2010 container trials..... 51

Table 17. One way ANOVA table for 2010 container VWC (%) by treatment. .... 51

Table 18. LS means for 2010 container VWC (%), SEM - standard error of the mean..... 52

Table 19. Average soil VWC (%) and total precipitation (m) measured weekly from 6-30 to 8-26 at Joe  
John and Highland Mary. .... 52

Table 20. Pooled cover for all plots in 2010 and 2011. .... 53

Table 21. 2010 and 2011 vegetation cover at Bonner, Highland Mary, and Little Molas..... 53

Table 22. 2010 and 2011 vegetation cover (%) for field plots by treatment..... 53

Table 23. Least squares means for field cover for 2010 and 2011 at mining and non-mining affected sites  
..... 54

Table 24. Least squares means for field cover for 2010 and 2011 at acid and non-acid affected sites..... 54



Peltz 2012. Biochar Data Summary 2011

Table 25. Above ground biomass (g) for all biochar and non-biochar treatments for 2010 container trials. .... 55

Table 26. Median and Interquartile range for above ground biomass (g) by treatment for the 2010 container trials..... 55

Table 27. Average above ground dried biomass (1 SD) by treatment and site. .... 55

Table 28. Above ground biomass (g) for container trials, grouped by mining and acid sites. .... 55

Table 29. Average vegetation heights (mm) measured at weekly intervals for each biochar treatment and soil control. .... 56

Table 30. pH measurements at the Evelyn Site in each of the biochar/ZI, and wood chip treatments..... 56

Table 31. pH measured at Eveline concrete tank outlet. .... 56

Table 32. Metal concentrations (ug/l) from each soil column treatment following 7 days of flow. .... 57

Table 33. Seed mix used at the Joe John Repository..... 57

Table 34. Joe John biochar application amounts. .... 57

Table 35. Joe John average and maximum carbon % by volume for collected soil cores..... 57

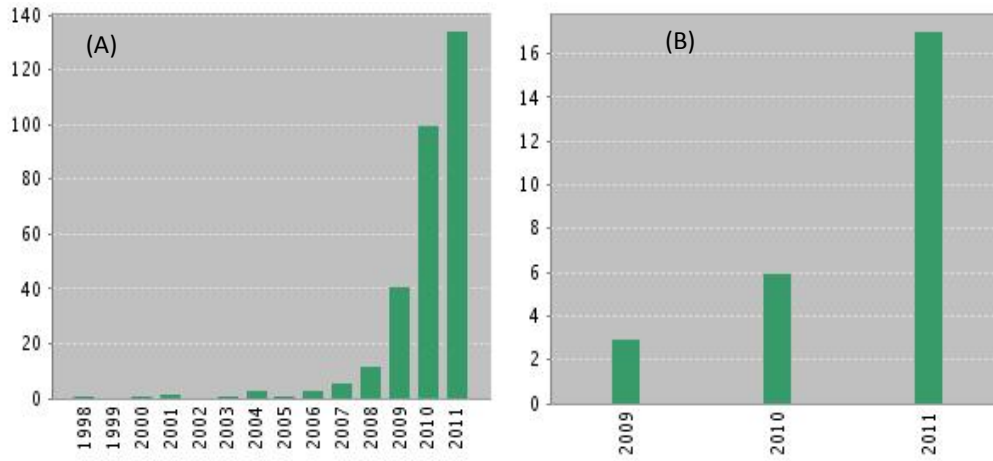


Figure 1. Biochar publications (A) and publications addressing mine lands remediation (B)

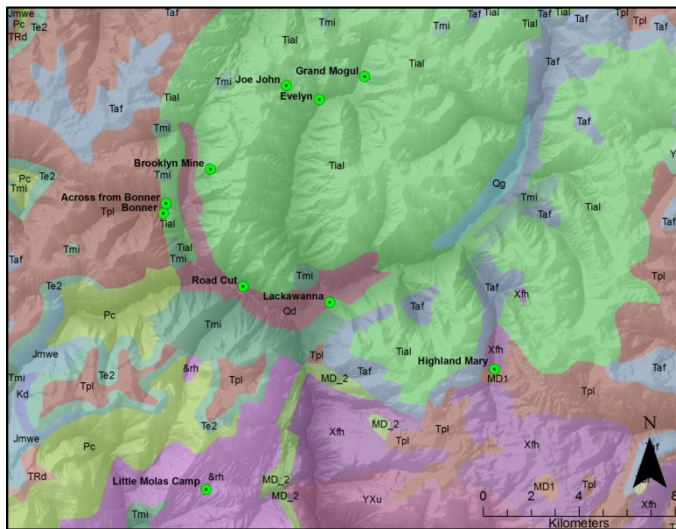


Figure 2. Generalized geology of the Upper Animas basin.



Figure 3. Topography in the Upper Animas Basin.

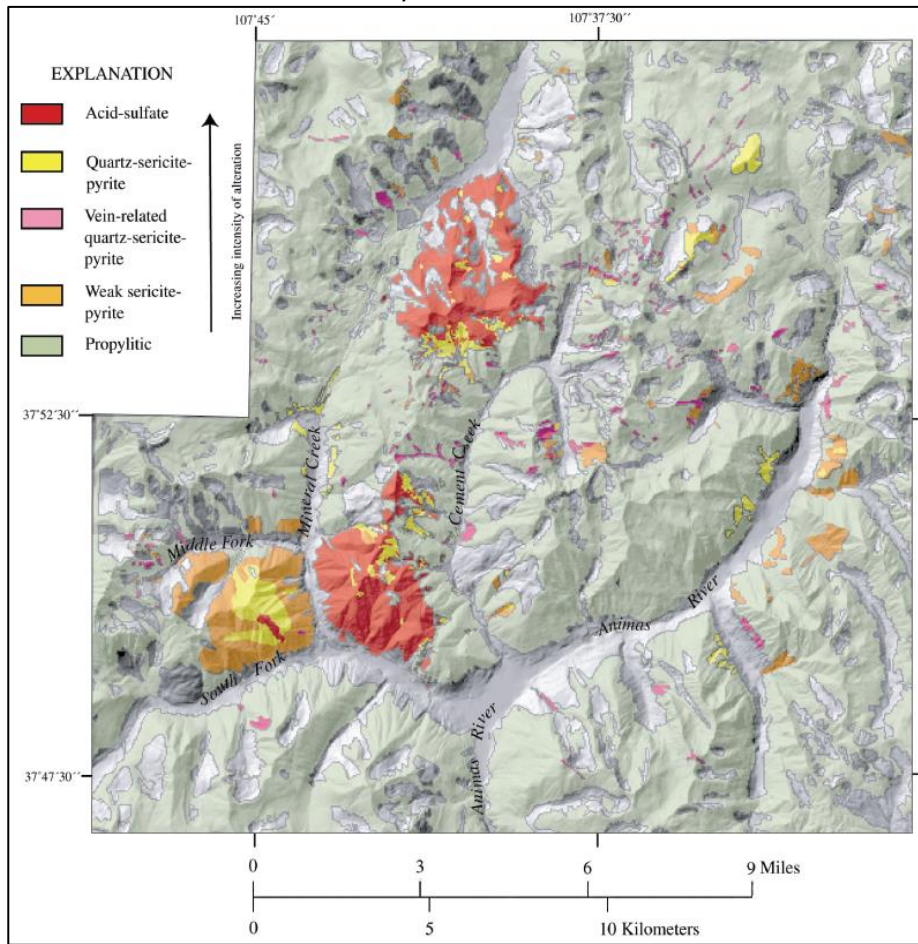


Figure 4. Generalized map of alteration types in the Upper Animas, From Yager et al 2008.

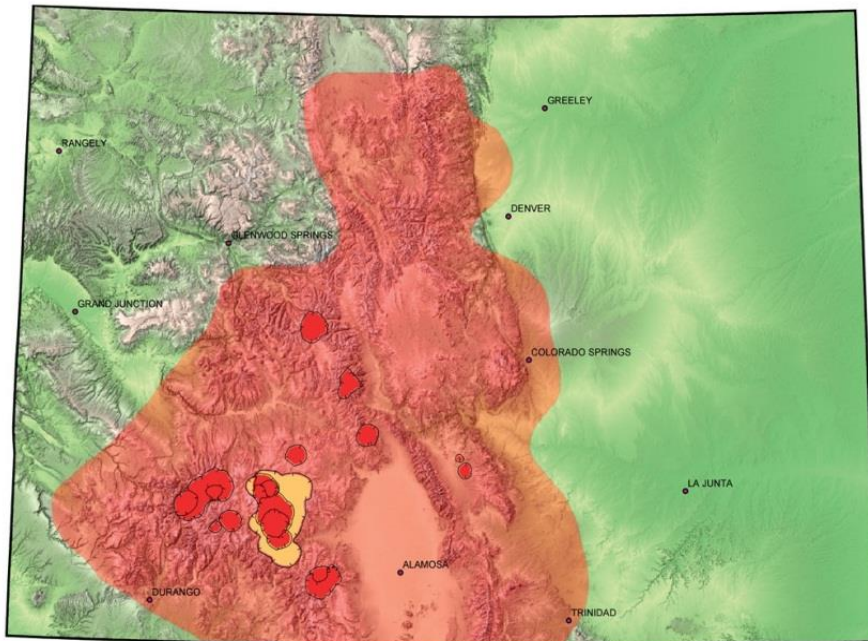


Figure 5. San Juan volcanic field (Colorado Geological Society).

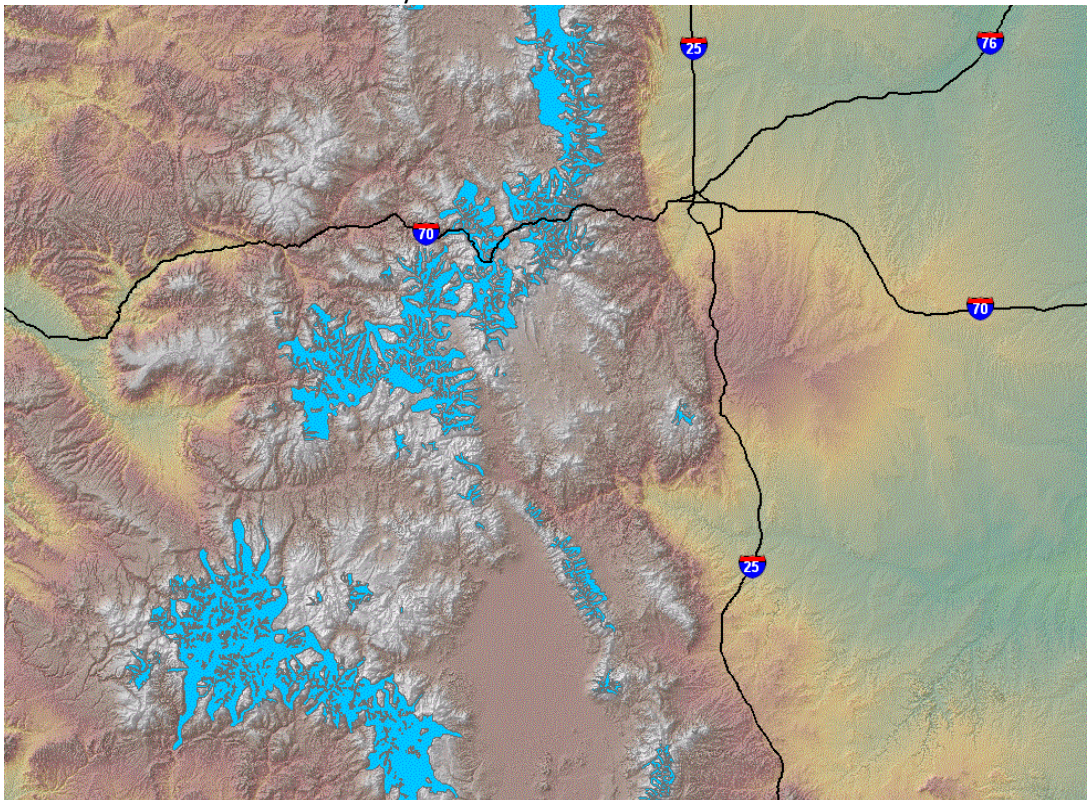


Figure 6. Pleistocene glacial extent at maximum phase ~18,000 YBP (Skinner and Porter, 1987).

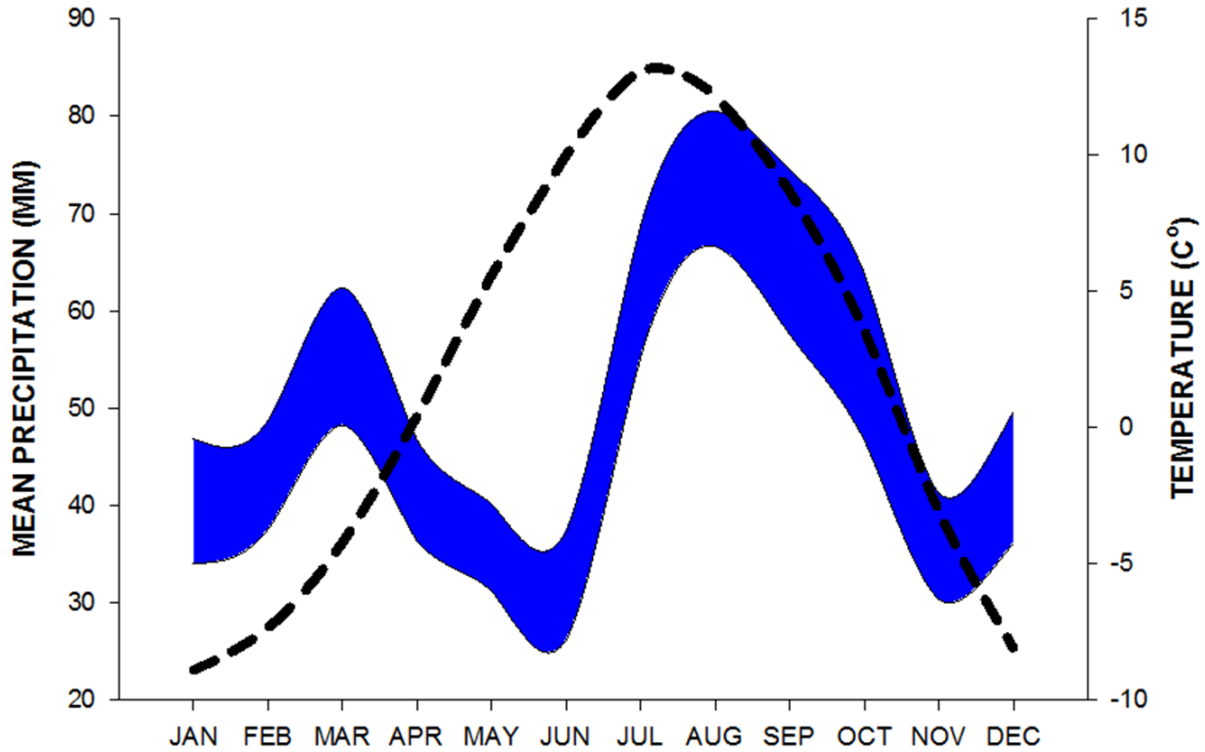


Figure 7. Mean and 95% confidence interval for monthly precipitation (blue) and mean temperature (dashed) for Silverton (from Western Regional Climate Center – WRCC, 3/1/1899 – 10/31/2011).

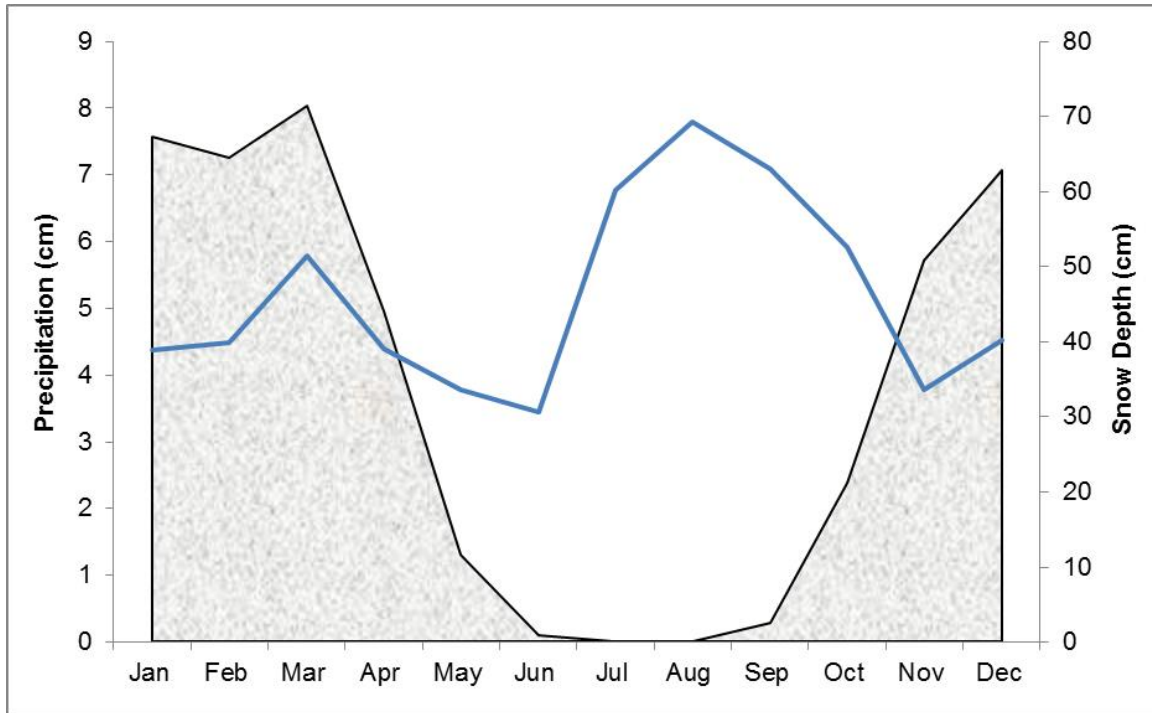


Figure 8. Average snow depth (grey) and precipitation by month (blue) from WRCC (3/ 1/1899 to 10/31/2011)

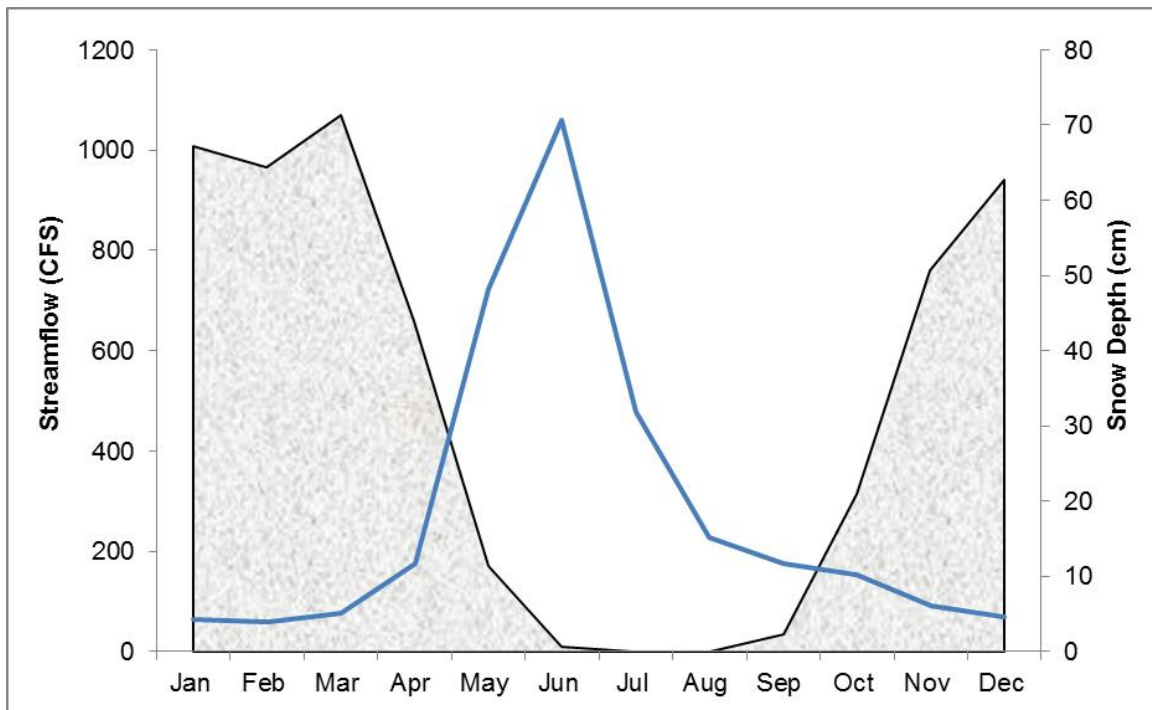


Figure 9. Average snow depth (grey) from WRCC (3/ 1/1899 to 10/31/2011) and stream flow (blue) in the Animas below Silverton, CO, USGS stream gage 09359020.



Peltz

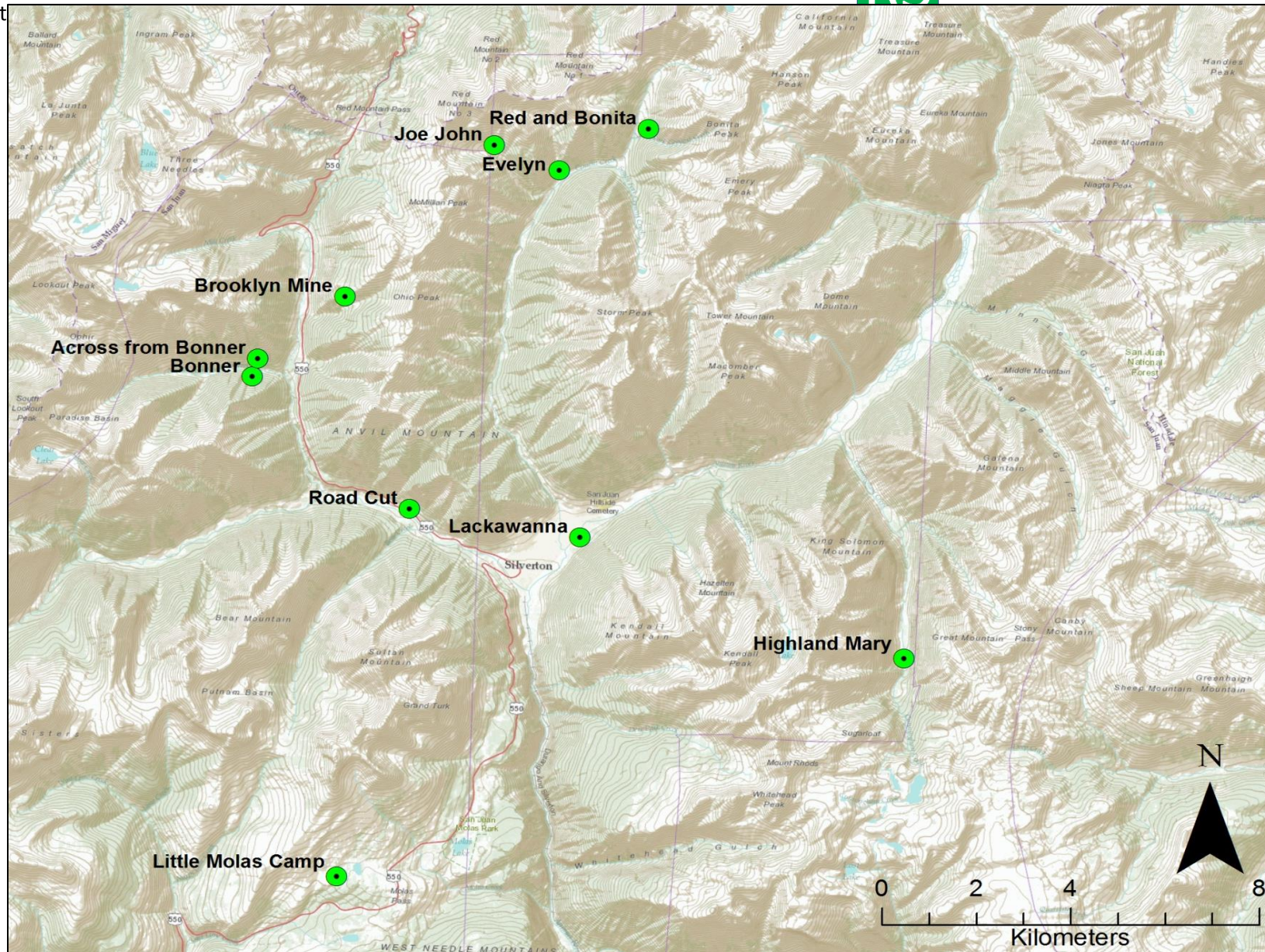


Figure 10. Biochar tests sites in the Upper Animas Basin.



Figure 11. Bonner site map.

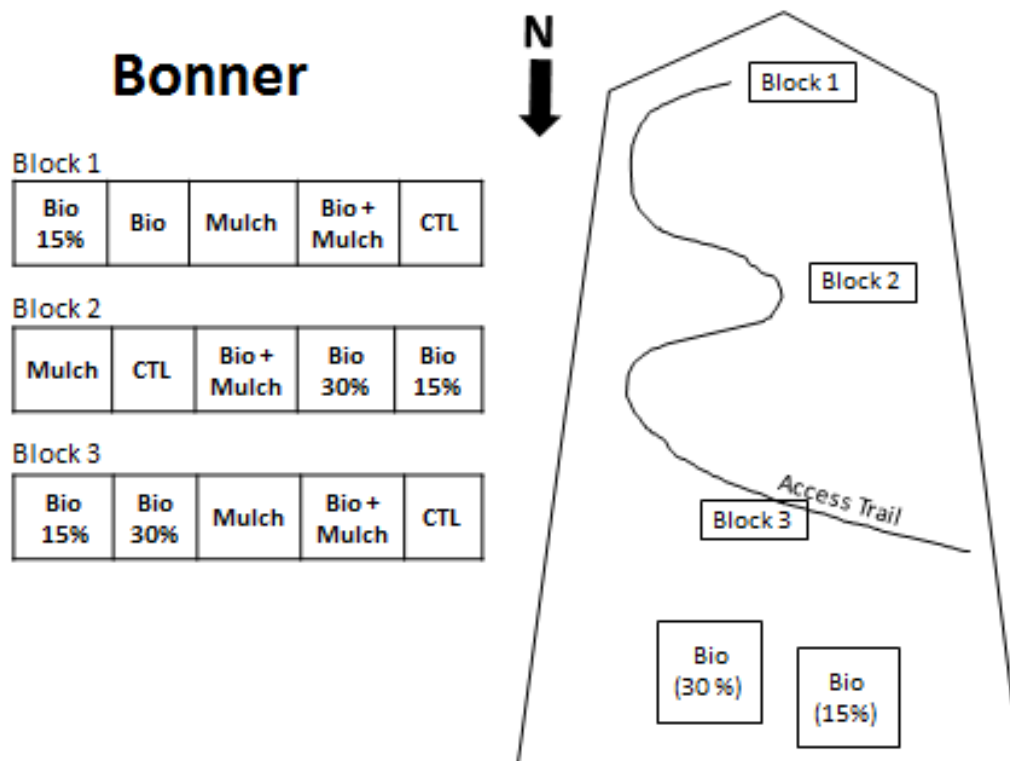


Figure 12. Bonner site map.



Figure 13. Bonner 5 X 5 meter plots (a – 30%) (b – 15%).



Figure 14. Biochar flume at Bonner draining adit.



**Figure 15. Joe John repository site**

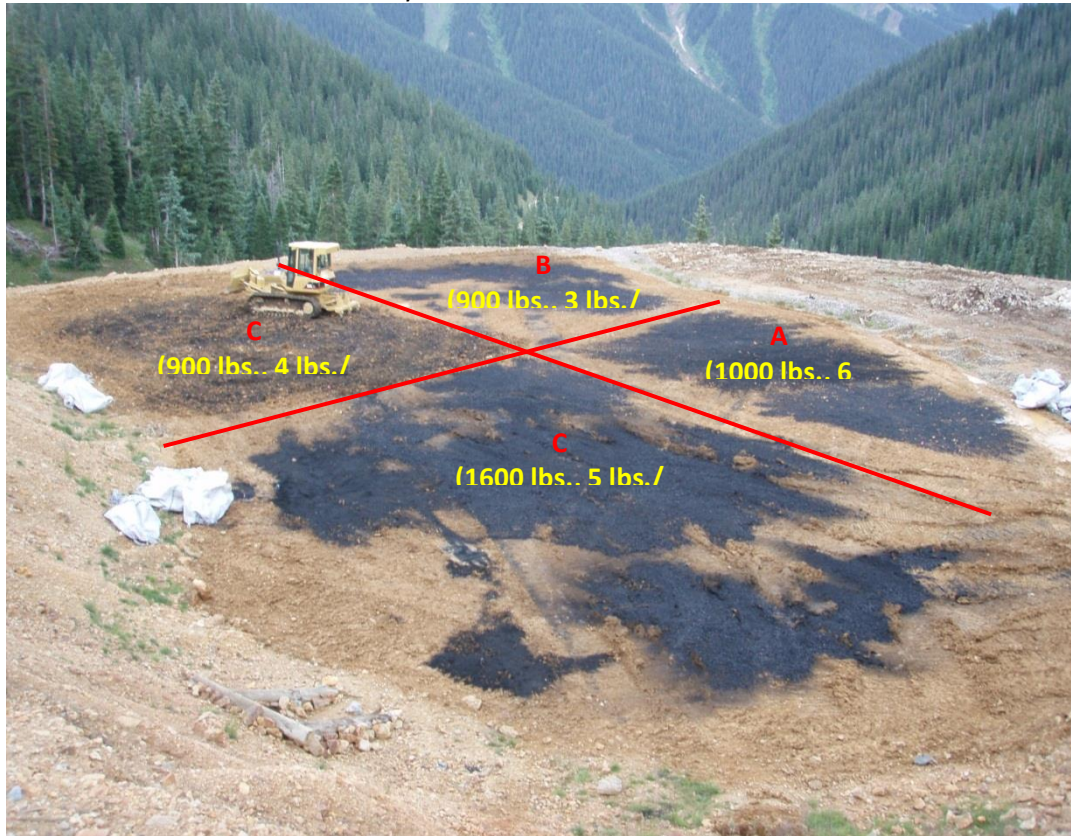


Figure 16. Joe & John repository quadrants and rates indicated in red (% in yellow).



Figure 17. Lackawanna mill site



**Figure 18. Site map of the Lackawanna Mill.**



**Figure 19. Highland Mary site map.**



Figure 20. Plot location at Highland Mary site.



Figure 21. Little Molas Campground (June 2010).



Figure 22. Brooklyn site with plots on the lower level.



Figure 23. Brooklyn site map.



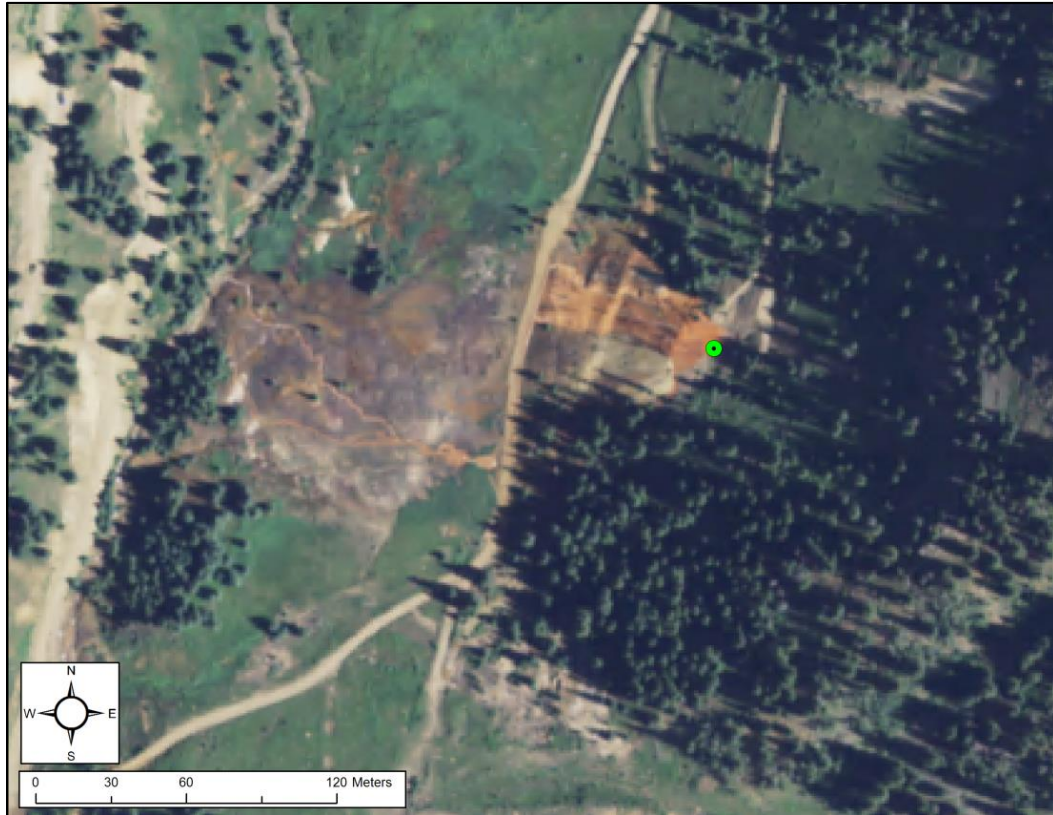


Figure 24. Red and Bonita Site.



Figure 25. Red and Bonita site image from north of pile.



Figure 26. Road Cut soil collection site.



Figure 27. Across from Bonner site map.



Figure 28. Eveline Site Map.



Figure 29. Column experiment at the Eveline Mine.



Figure 30. Boston Mine Site

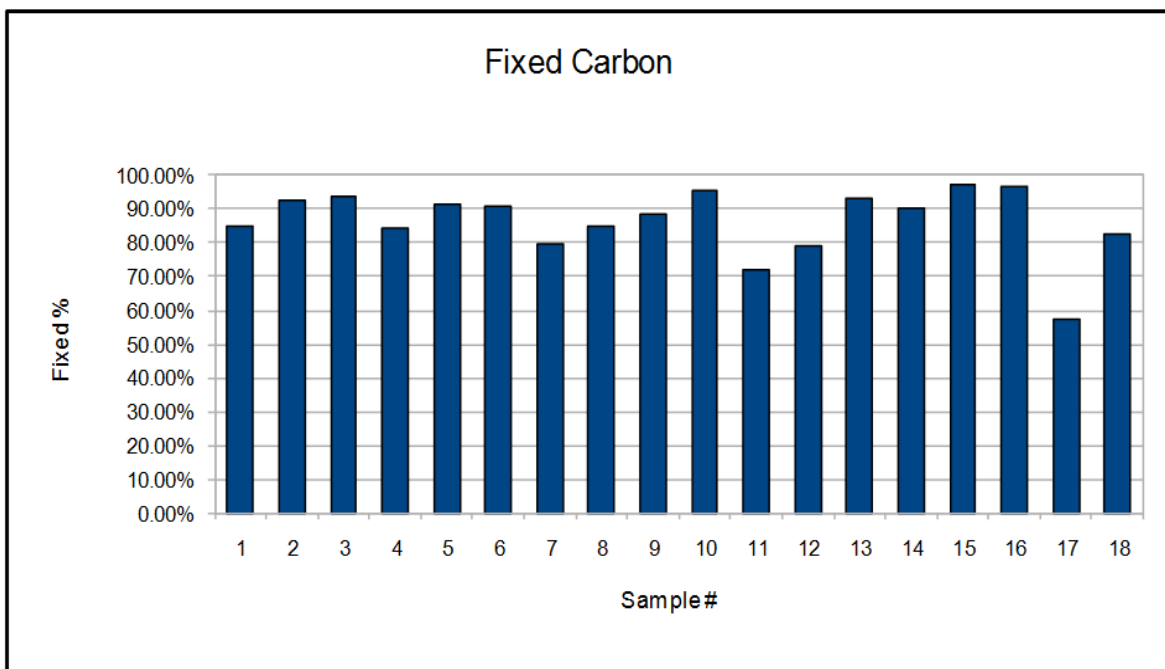
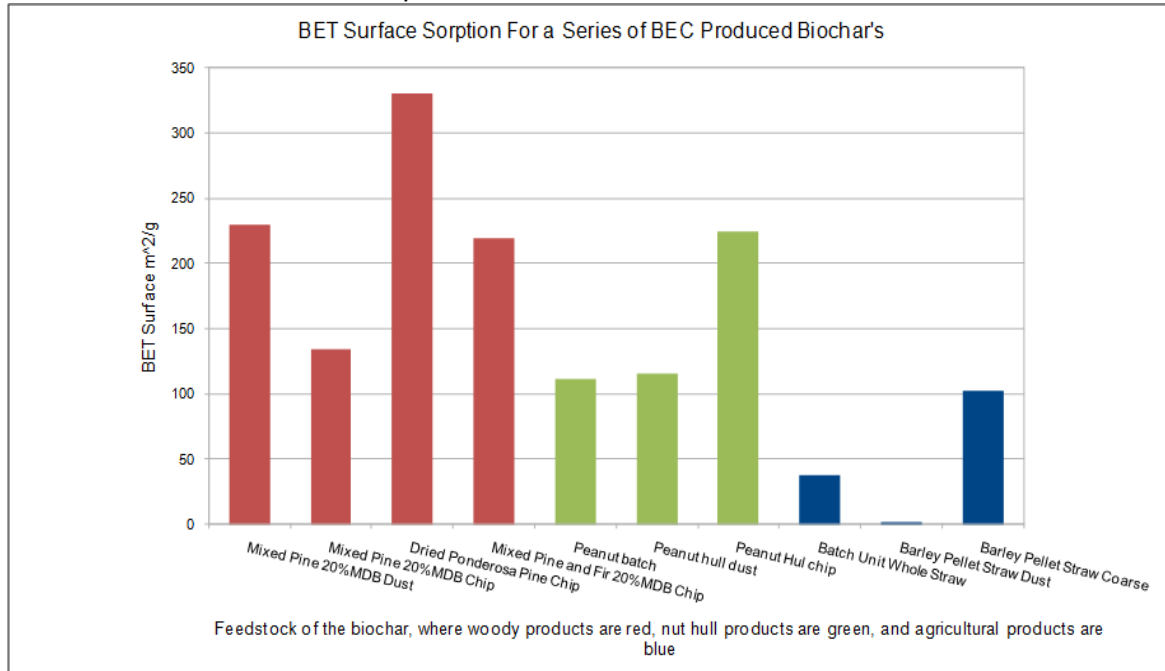


Figure 31. BSI BET surface area (m<sup>2</sup>) and fixed carbon (%).

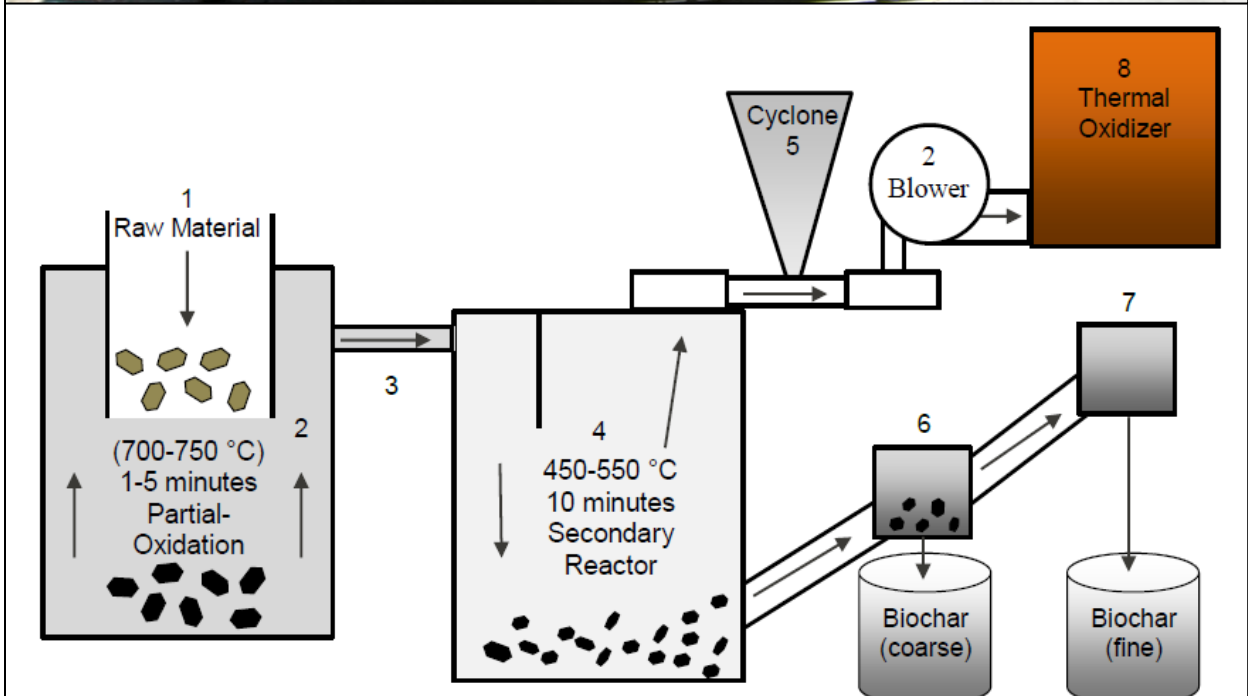


Figure 32. Biochar Engineering mobile biochar production unit.



Figure 33: BSI Base Unit, conveyor dryer and oxidizer December 2011, Pueblo Colorado.



Figure 34. Colorado Biochar LLC, field pyrolysis unit.

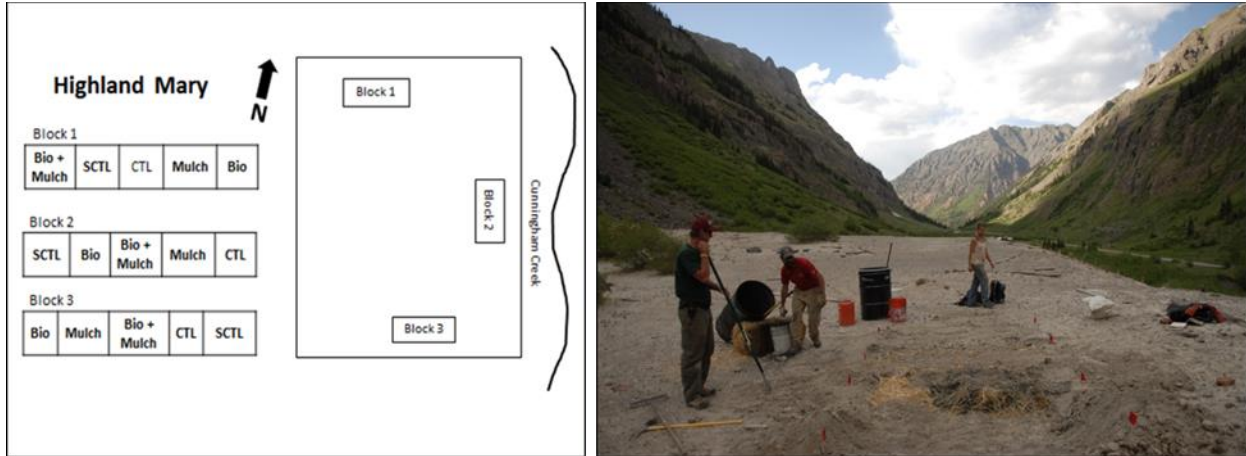


Figure 35. Example layout and plot installation at the Highland Mary site

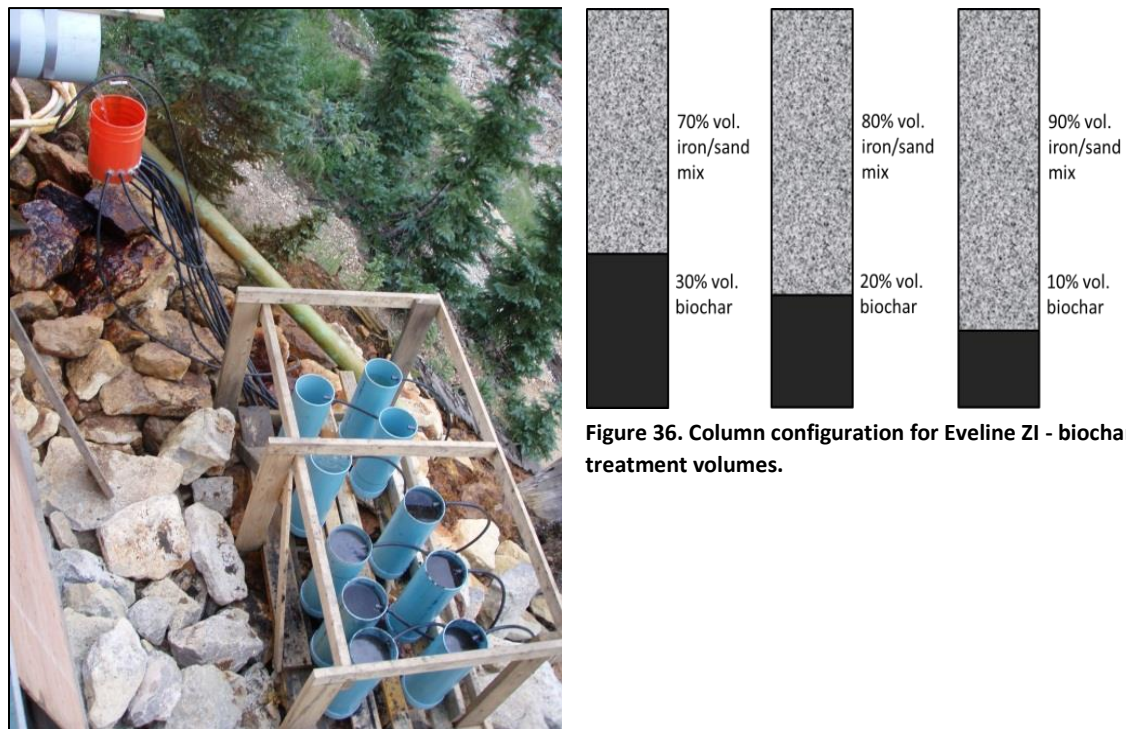


Figure 36. Column configuration for Eveline ZI - biochar treatment volumes.

Figure 37. Eveline AMD water treatment columns.



Figure 38. Eveline mine draining adit (A) and treatment columns (B)



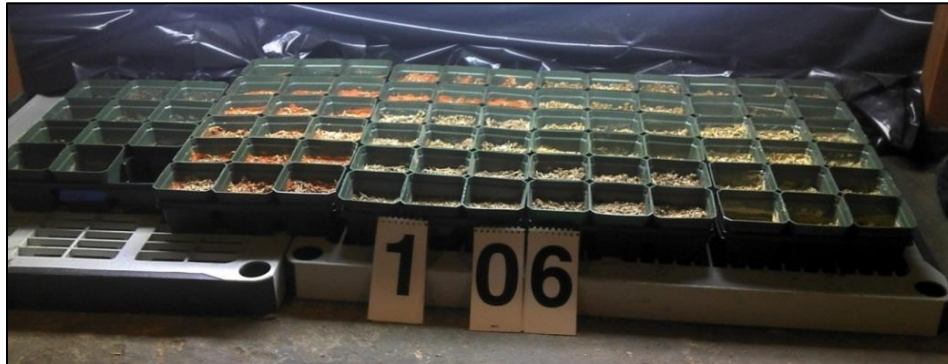


Figure 39. Greenhouse trials 1-6-2012.

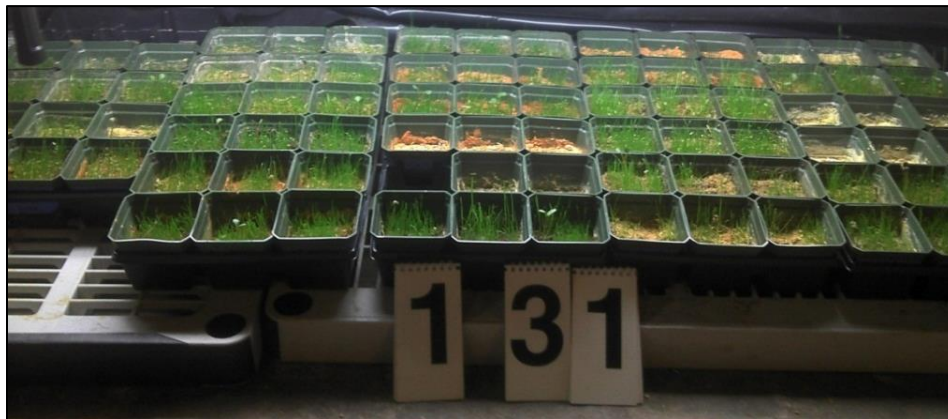


Figure 40. Greenhouse trials January 31, 2011.



Figure 41. Greenhouse experiments March 6, 2012.

Peltz 2012. Biochar Data Summary 2011

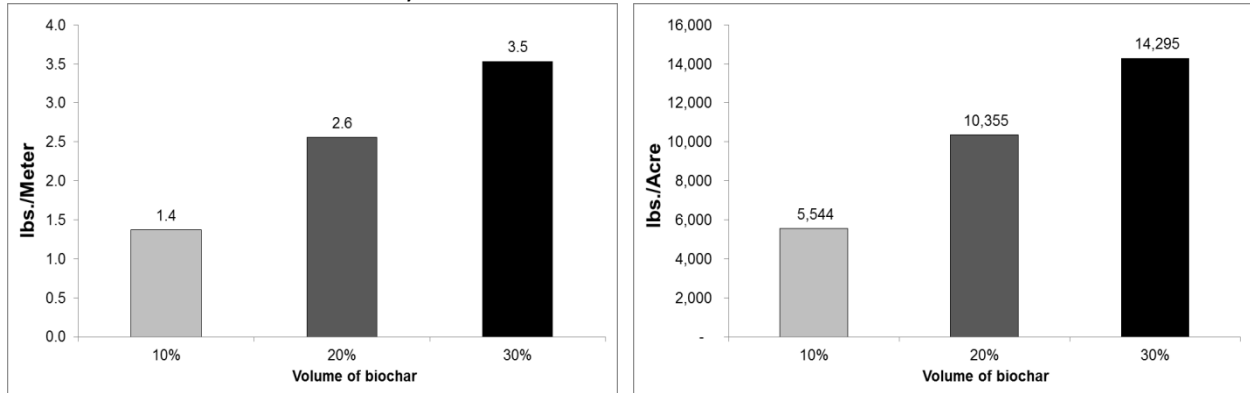


Figure 42. Biochar additions for 2012 greenhouse experiments in lbs./Meter and lbs./Acre.



Figure 43. Biochar application at the Joe John site.



Figure 44. Incorporating biochar at Joe John site.

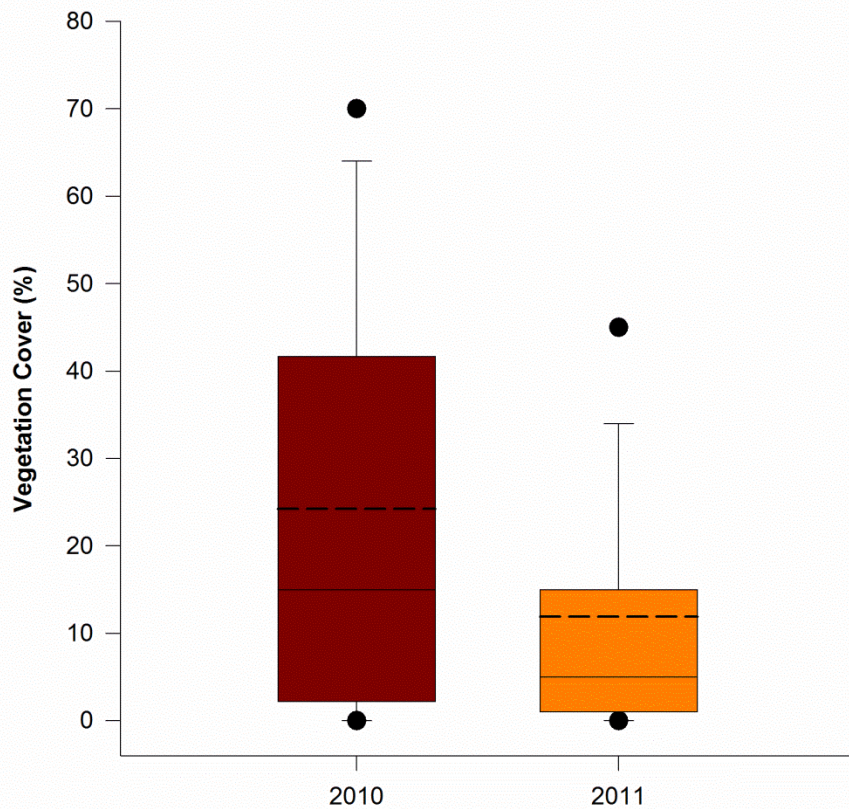


Figure 45. Vegetation cover (%) for all field plots in 2010 and 2011, dashed line indicates mean.

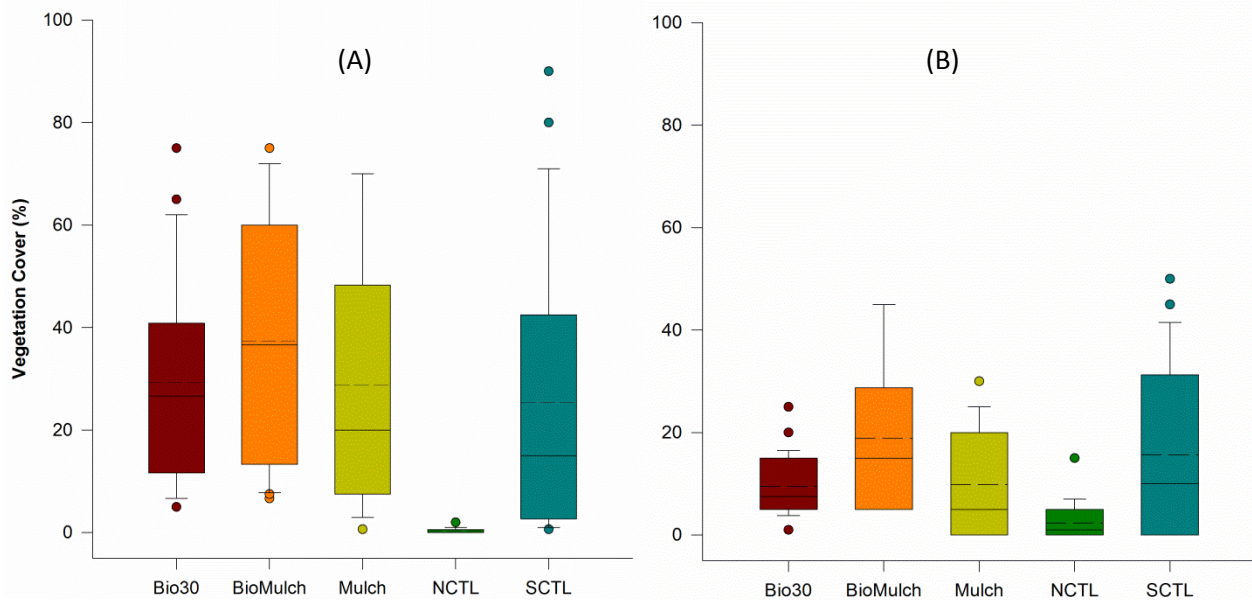


Figure 46. 2010 (A) and 2011 (B) vegetation cover in biochar treatment plots, dashed lines indicate mean. Bio30 – 30% biochar volume, BioMulch – 30% biochar + straw mulch, NCTL – No seed control, Mulch – Straw Mulch, SCTL – Seed only control (50g/m<sup>2</sup>).

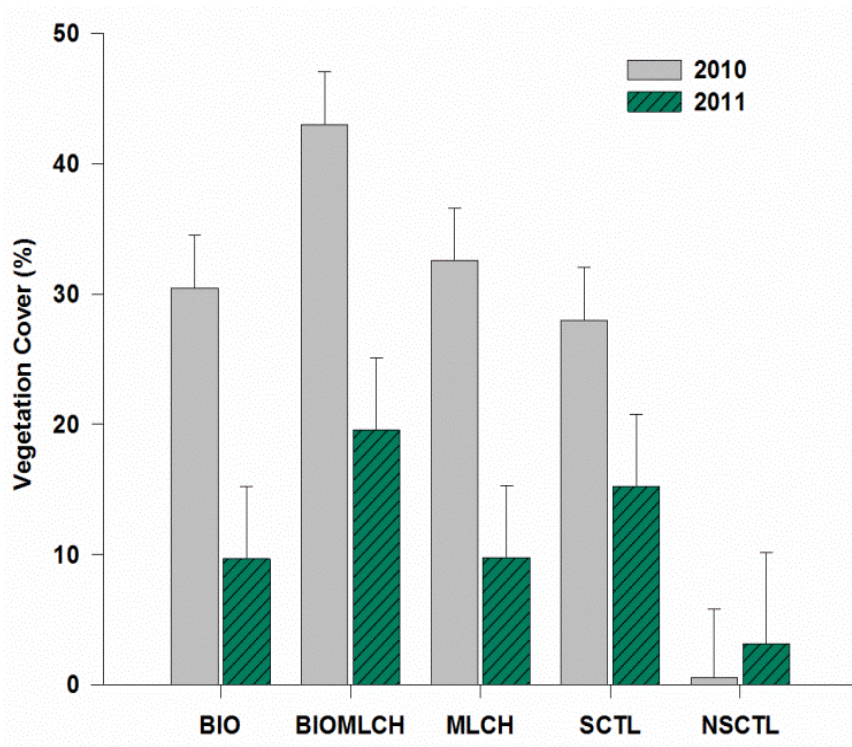


Figure 47. Vegetation cover (%) by treatment and year.

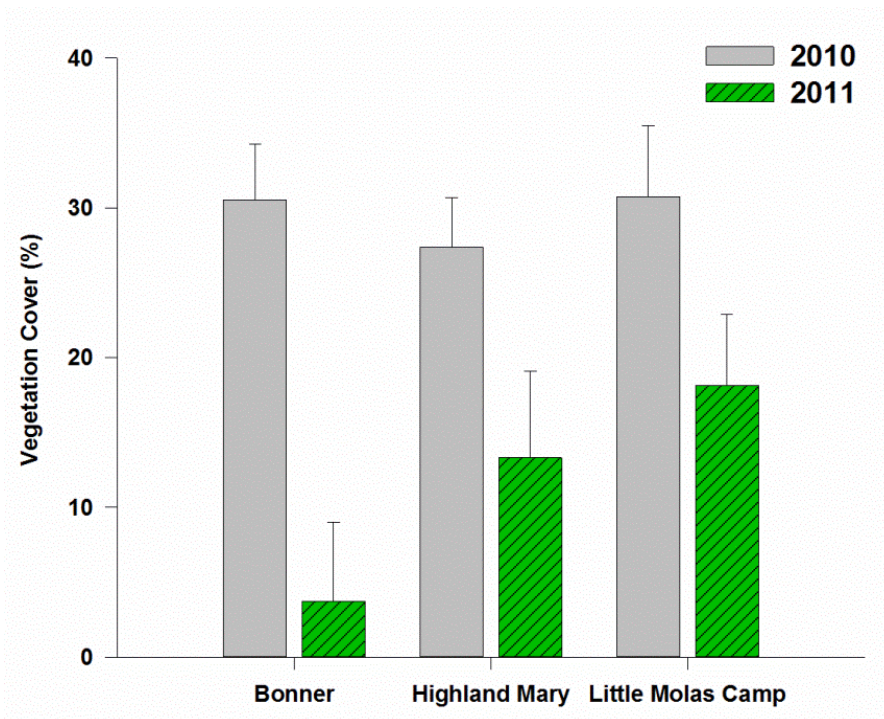


Figure 48. Total cover in 2010 and 2011 for Bonner, Highland Mary, and Little Molas Camp.

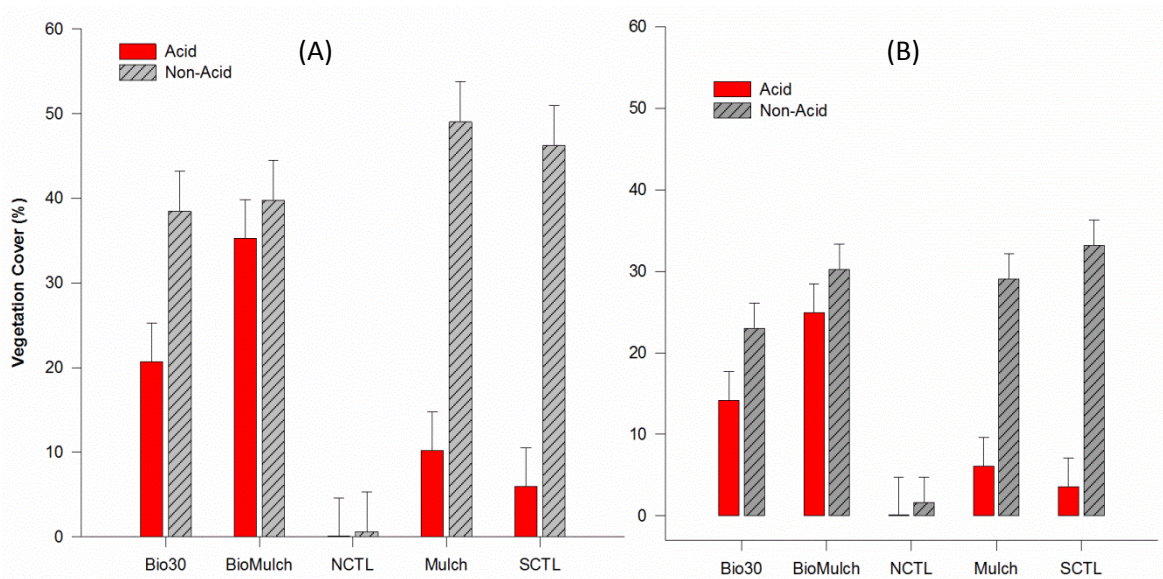


Figure 49. 2010 (A) 2011 (B) field cover for biochar test plots at Acid (Bonner, Joe John, Lackawanna) and Non-Acid (Highland Mary, Little Molas) sites.

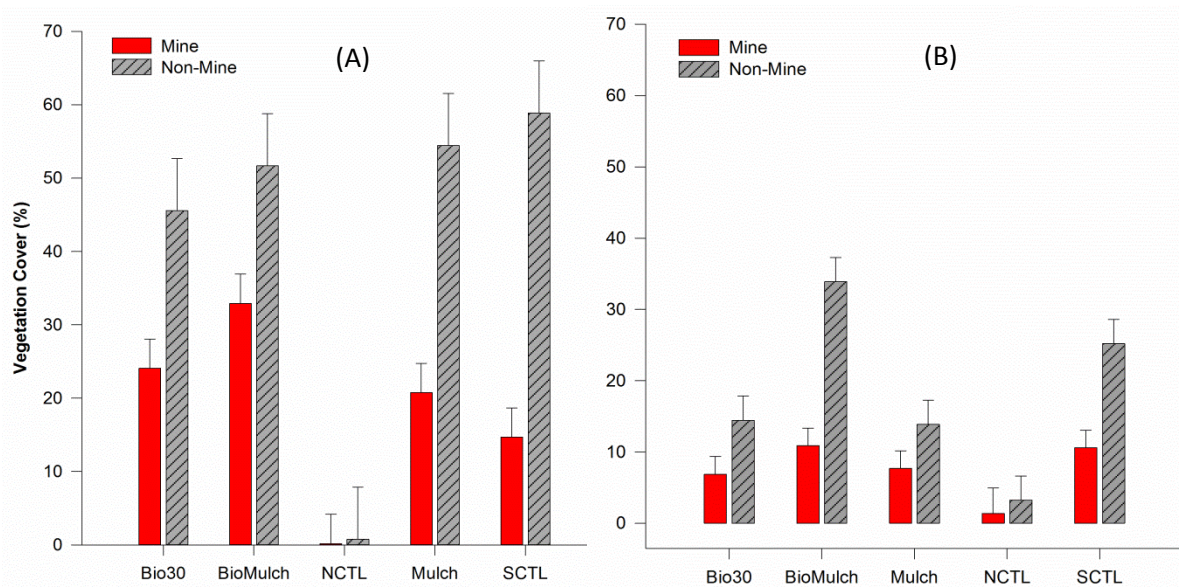


Figure 50. 2010 (A) 2011 (B) field cover for biochar test plots at Mine (Bonner, Joe John, Lackawanna, Highland Mary) and Non-Mine (Little Molas) sites.

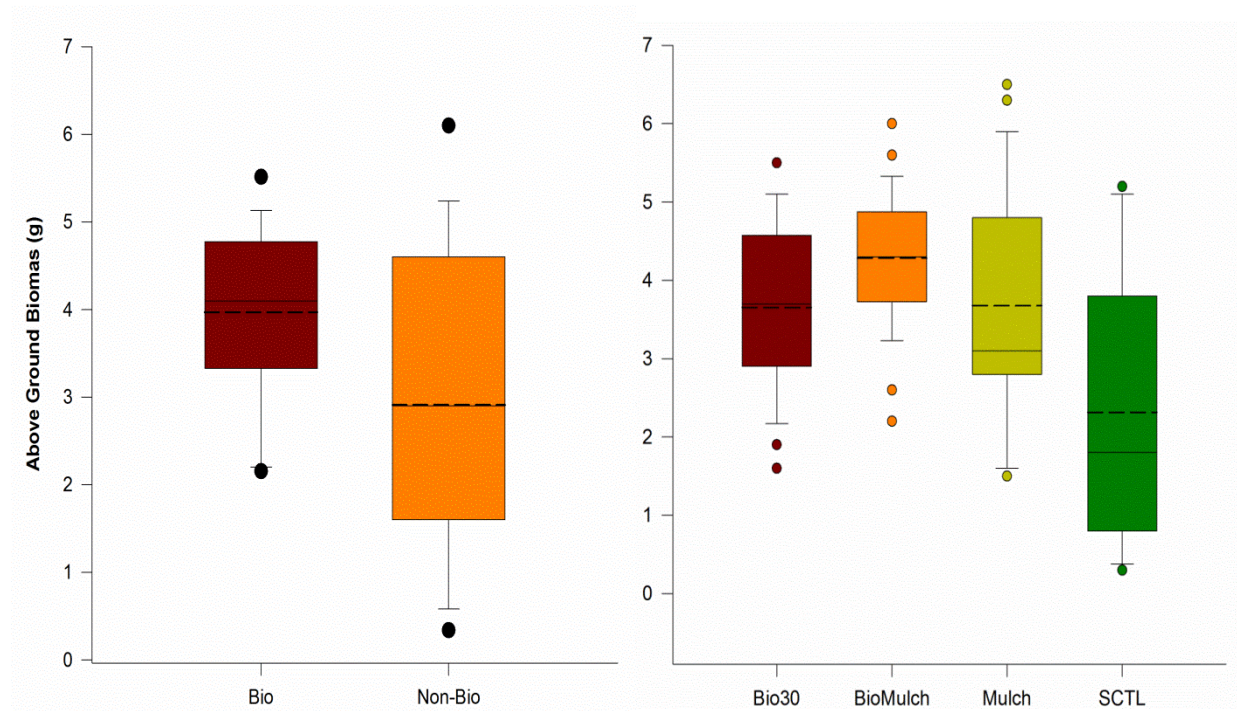


Figure 51. Above ground biomass (g) for biochar (n = 3) and non-biochar (n = 3) and by treatment for 2010 container trials.

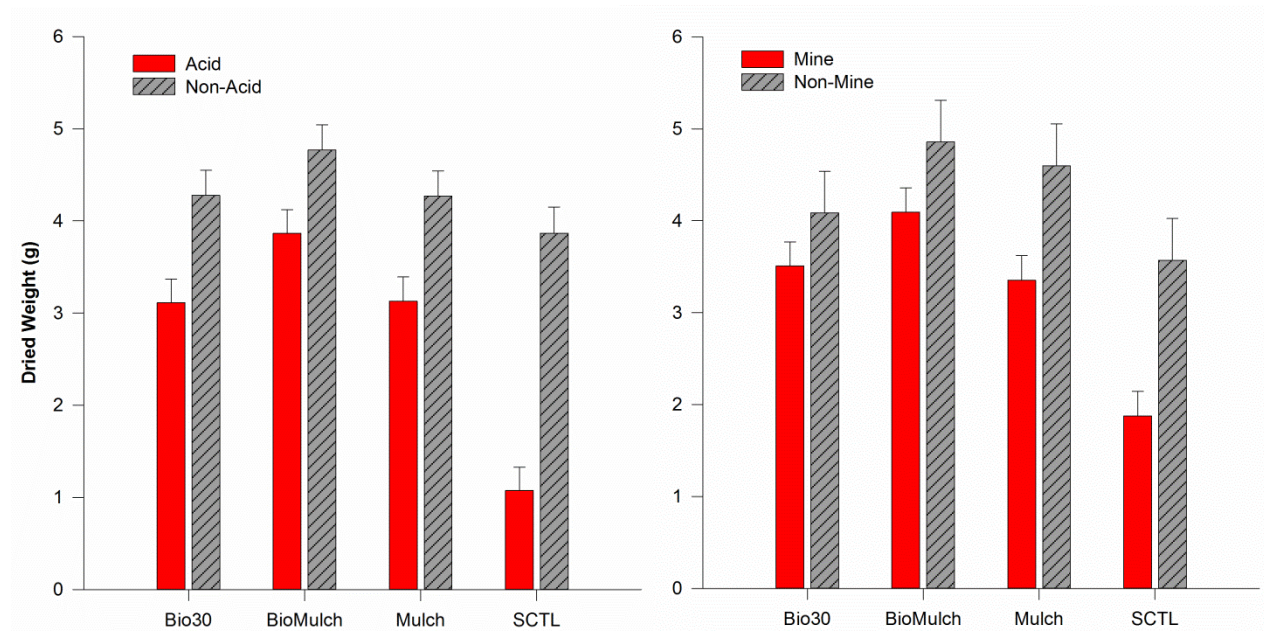


Figure 52. Above ground biomass for acid and non-acid (A) and mining and non-mining (B) affected sites.



Figure 53. Greenhouse/container trials 2010.



Figure 54. Containers at 40 days with soils from Highland Mary (mining, non-acid site).



Figure 55. Containers at 40 days with soils from Bonner (mining, acid site).

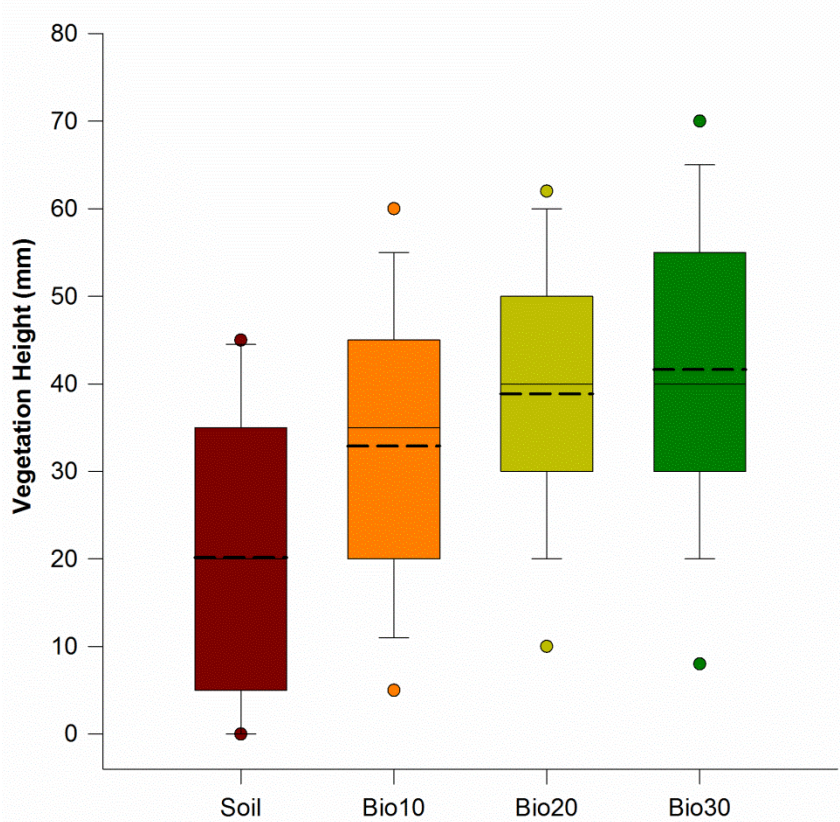


Figure 56. Range of height values by treatment for 2012 greenhouse trials, dashed lines indicate mean.

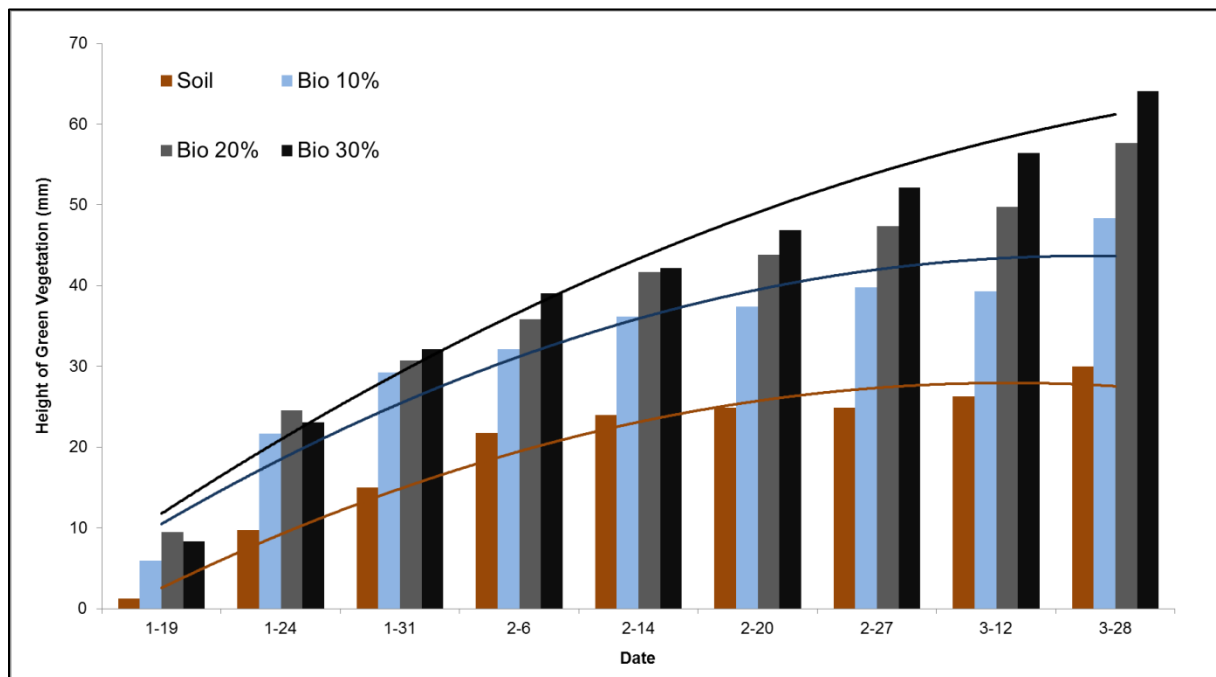


Figure 57. Height of green vegetation (mm) measured in 2012 container trials at weekly intervals, bars are values at each time step, lines indicate 2<sup>nd</sup> order polynomial regression fit to height data.



### Soil Moisture

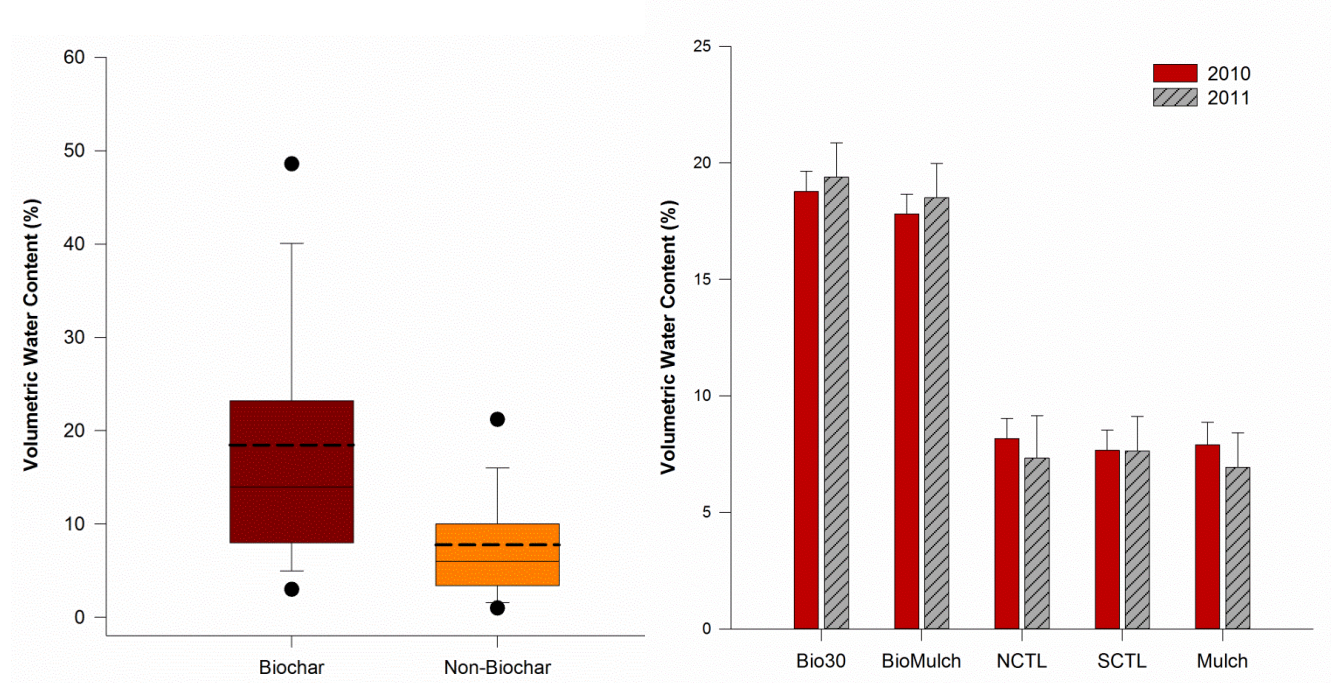


Figure 58. Soil volumetric water content.

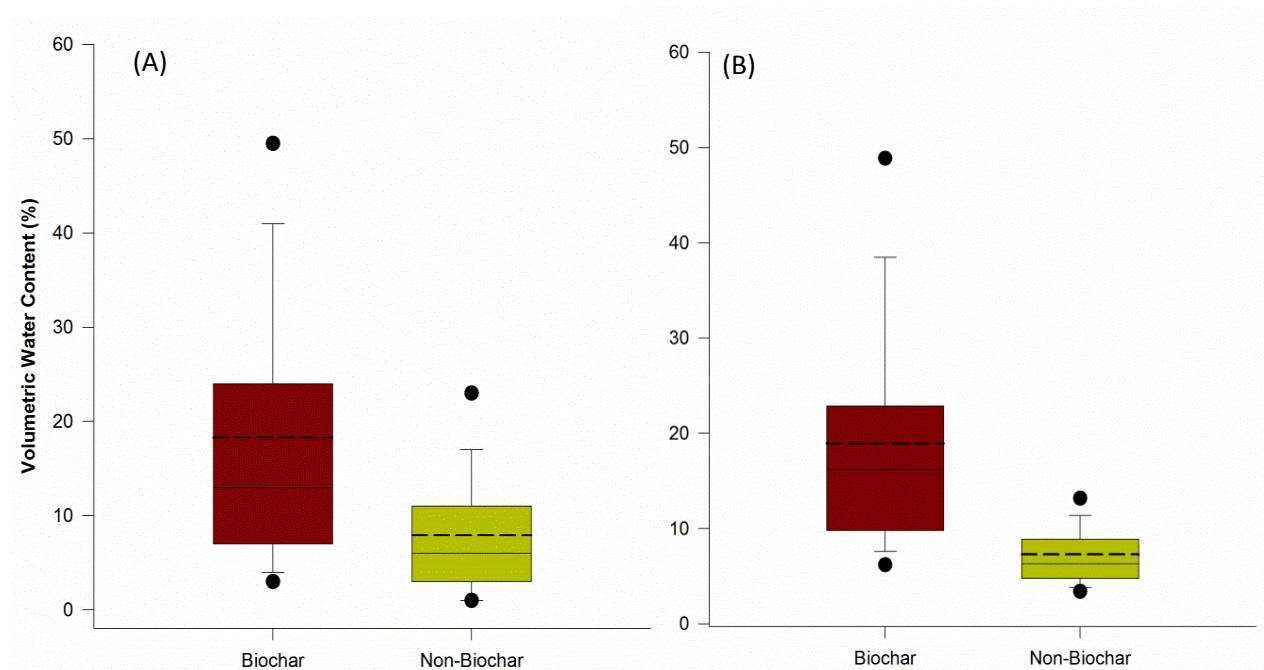


Figure 59. 2010 (A) and 2011 (B) field VWC (%) for biochar and non-biochar amended plots, dashed lines indicate mean, and differences in VWC are significant at  $p < 0.001$ .

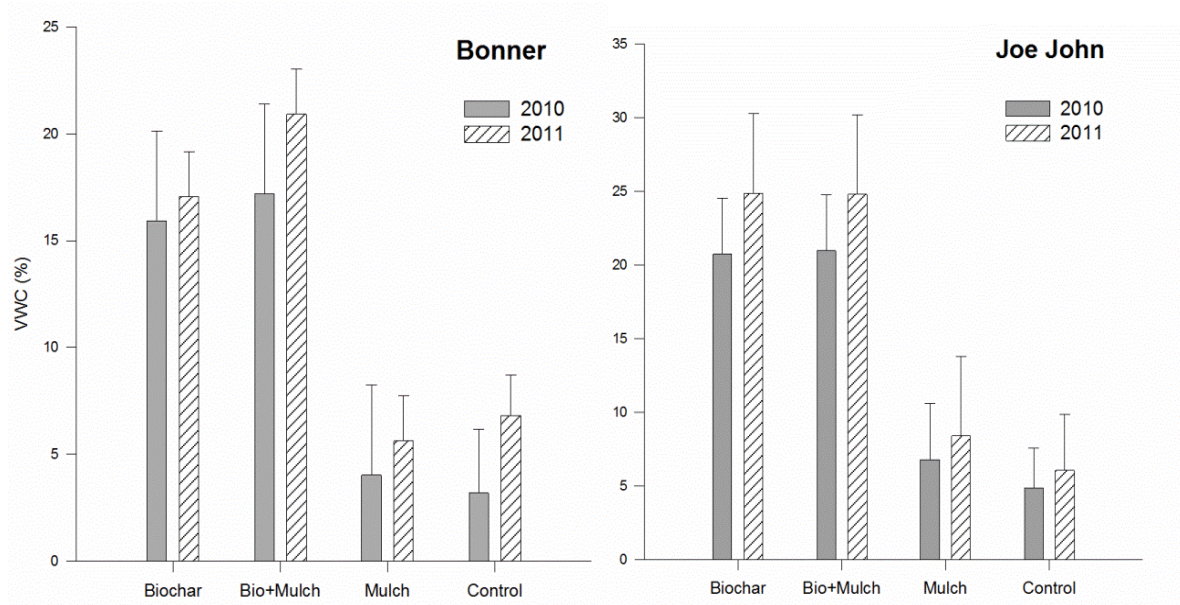


Figure 60. Volumetric water content (%) for Bonner and Joe John sites in 2010 and 2011.

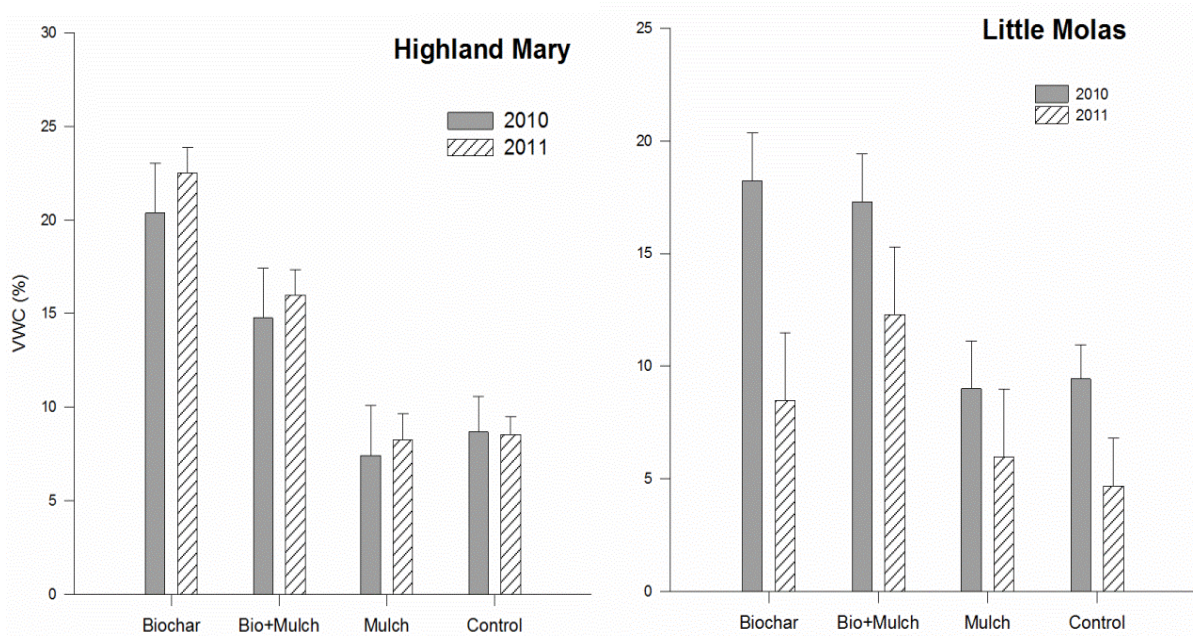


Figure 61. Volumetric water content (%) for Highland Mary and Little Molas Campground in 2010 and 2011.

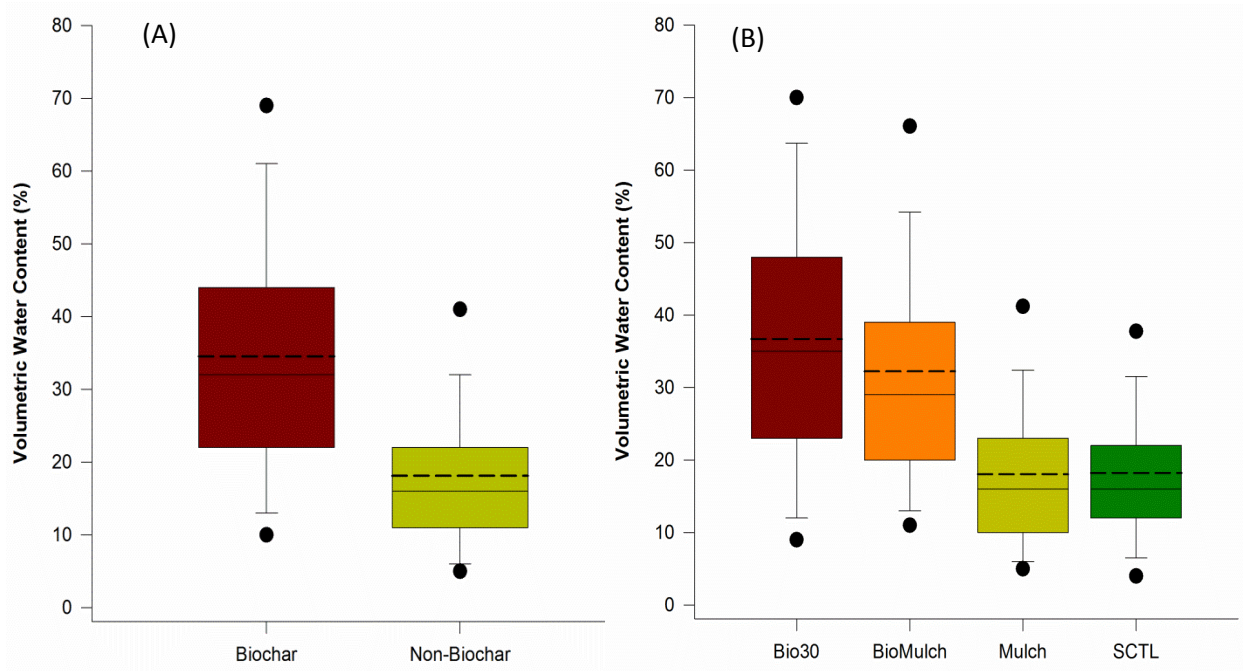


Figure 62. Volumetric water content (%) for container trials by biochar vs. non-biochar (A), and by treatment (B).

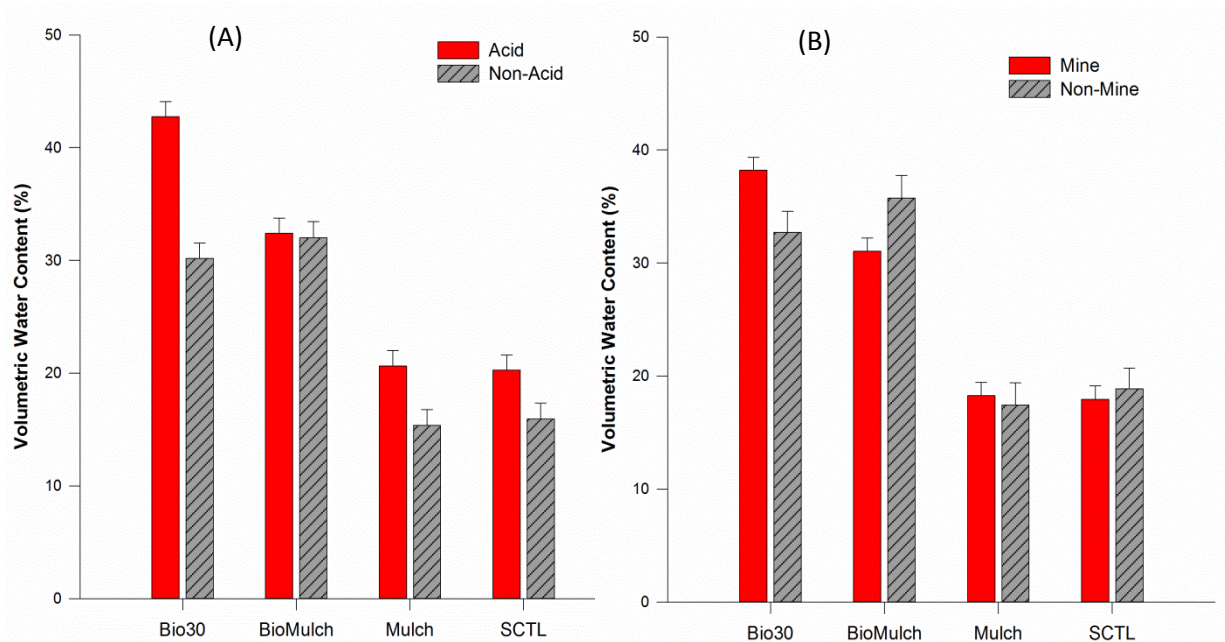


Figure 63. 2010 container VWC (%) by acid sites (A) and by mining affected sites (B).

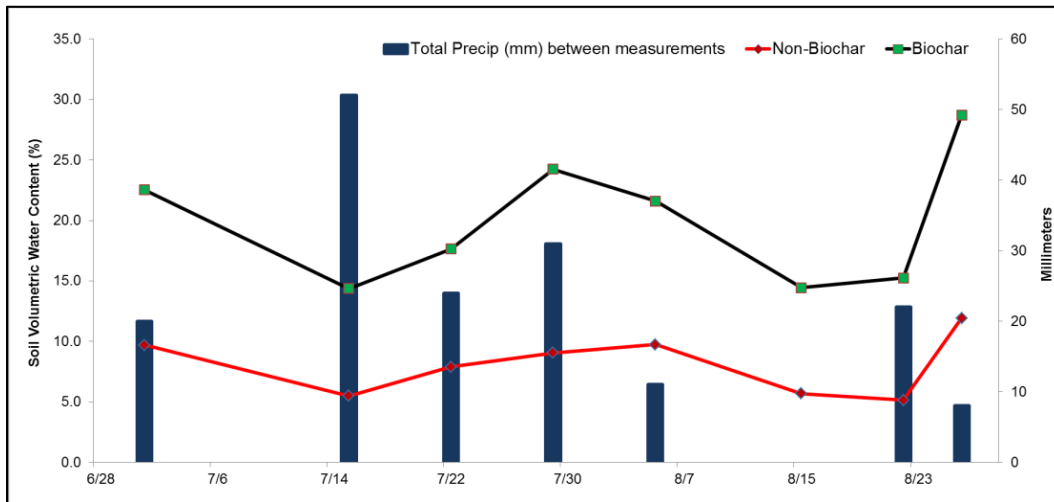


Figure 64. Soil VWC through time for combined biochar treatments.

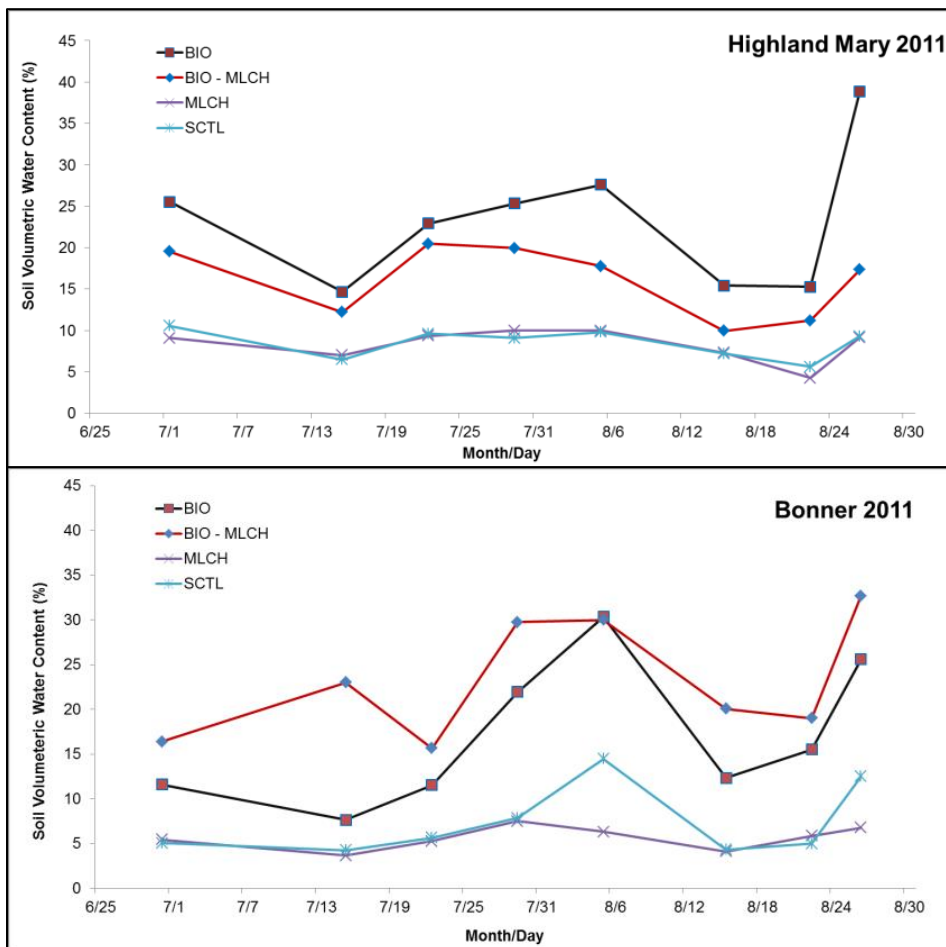


Figure 65. Soil VWC measured at 7 day intervals at the Bonner and Highland Mary site 2011

Peltz 2012. Biochar Data Summary 2011

BONNER	8/27	9/4	9/10	9/27
<b>Al</b>				
BIOCHAR	4.42	6.38	3.32	
SOIL	8.69	8.19	6.64	
<b>As</b>				
BIOCHAR	0.10	0.11	0.08	0.10
SOIL	0.21	0.14	0.15	0.12
<b>Cd</b>				
BIOCHAR	0.04	0.05	0.06	0.03
SOIL	0.03	0.02	0.02	0.03
<b>Cu</b>				
BIOCHAR	0.20	0.33	0.17	0.30
SOIL	0.30	0.22	0.21	0.19
<b>Fe</b>				
BIOCHAR	33.67	38.87	26.77	
SOIL	67.03	64.13	55.23	
<b>Mg</b>				
BIOCHAR	3.93	4.67	3.00	
SOIL	5.23	4.80	3.37	
<b>Mn</b>				
BIOCHAR	1.07	1.58	1.28	1.34
SOIL	0.65	0.54	0.71	0.78
<b>Pb</b>				
BIOCHAR	2.14	2.49	1.35	1.23
SOIL	5.37	3.23	2.19	1.00
<b>Zn</b>				
BIOCHAR	6.58	7.85	6.65	6.19
SOIL	3.89	2.22	2.93	4.30

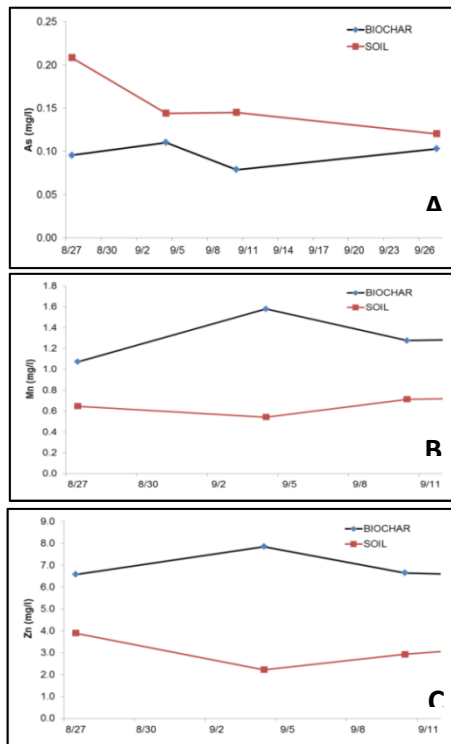


Figure 66. Soil leachate chemistry for Bonner 2010 (A – As. B - Mn. C – Zn. D – Fe).

JOE JOHN	8/27	9/4	9/10	9/27
<b>Al</b>				
BIOCHAR	6.09	1.69	1.45	
SOIL	1.84	1.30	2.34	
<b>As</b>				
BIOCHAR	0.011	0.004	0.004	0.006
SOIL	0.005	0.003	0.005	0.006
<b>Cu</b>				
BIOCHAR	0.08	0.02	0.04	0.05
SOIL	0.08	0.08	0.08	0.10
<b>Fe</b>				
BIOCHAR	15.70	4.51	3.47	
SOIL	3.87	3.12	5.64	
<b>Mg</b>				
BIOCHAR	1.90	0.70	0.80	
SOIL	0.70	0.60	0.70	
<b>Mn</b>				
BIOCHAR	0.29	0.10	0.21	0.19
SOIL	0.26	0.15	0.29	0.37
<b>Ni</b>				
BIOCHAR	0.01		0.02	
SOIL	0.02	0.01	0.02	0.02
<b>Pb</b>				
BIOCHAR	0.55	0.17	0.14	0.26
SOIL	0.16	0.11	0.22	0.29
<b>Zn</b>				
BIOCHAR	0.14	0.06	0.13	0.13
SOIL	0.22	0.27	0.21	0.25

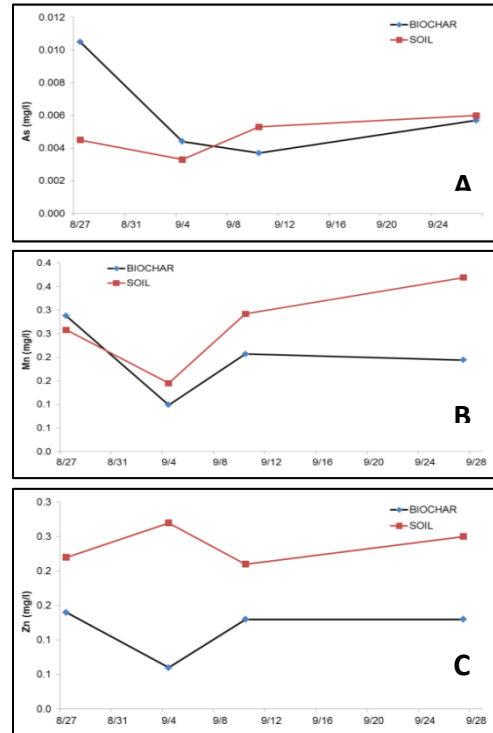


Figure 67. Average concentration (mg/L) for soil leachate for the Joe John Site - 2010 (A – As, B – Mn, C – Zn, D – Fe) Y axis are dates in 2010.

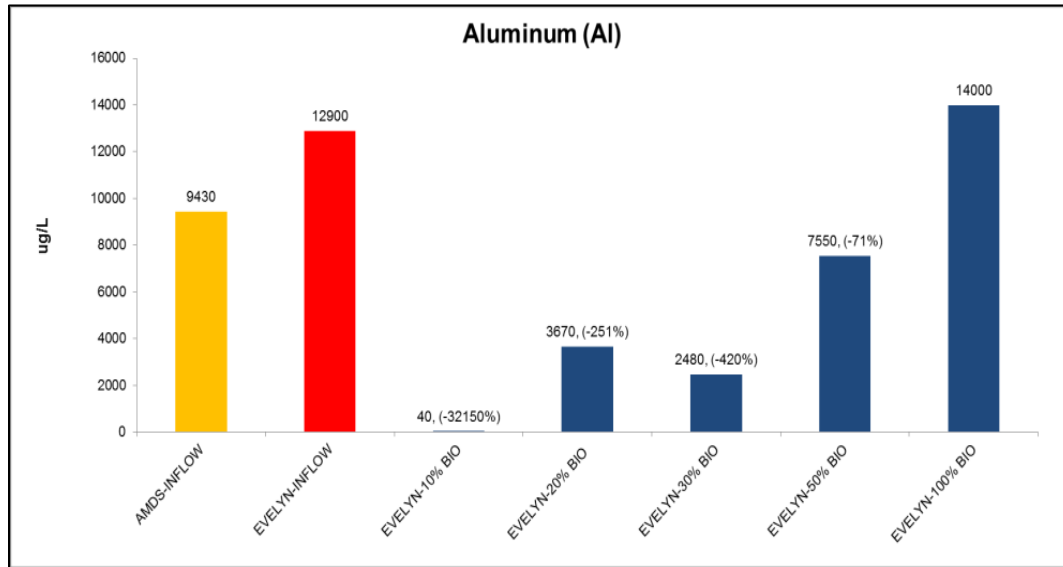


Figure 68. Aluminum, AMDS-Inflow values from Ford, Fleming and Odell (2009), values in parentheses represent % decrease from the Evelyn-Inflow values.

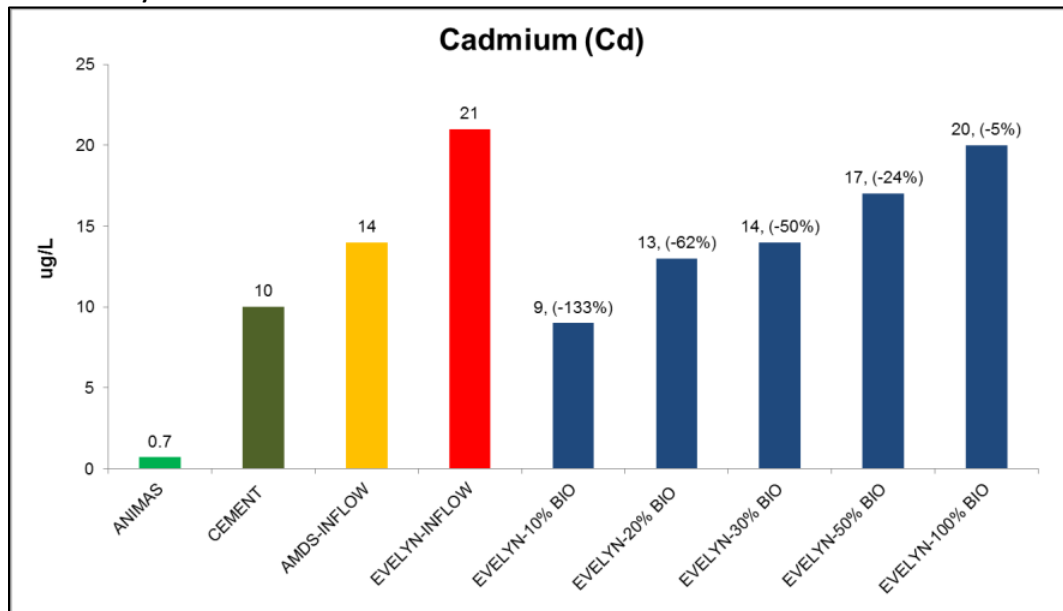


Figure 69. Cadmium, concentrations in effluent waters, biochar columns, and standard for Cement Creek (green).

Peltz 2012. Biochar Data Summary 2011

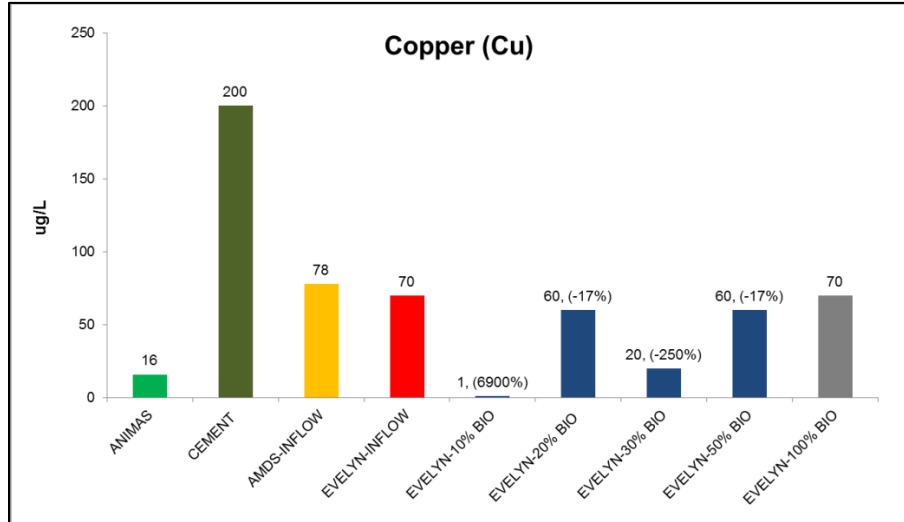


Figure 70. Total copper concentrations in effluent waters, biochar columns, and standard for Cement Creek (green).

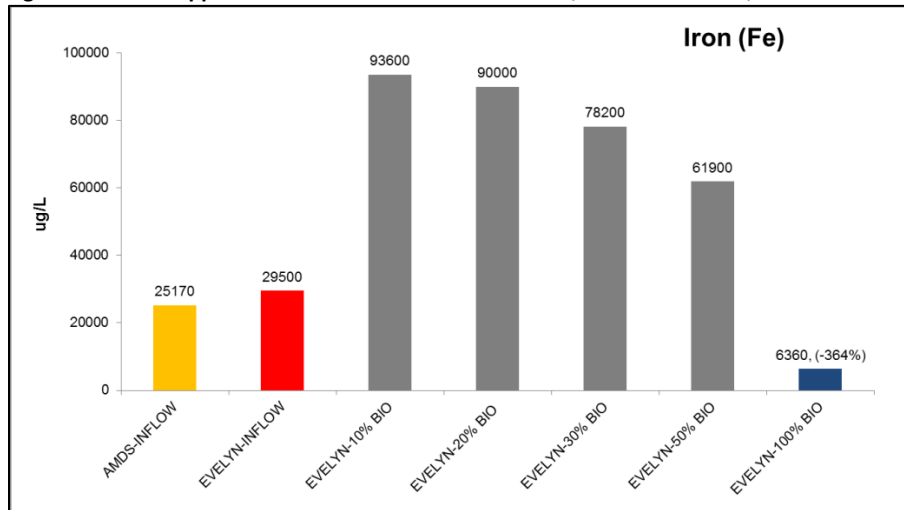


Figure 71. Iron concentrations and Evelyn outflow and biochar columns.

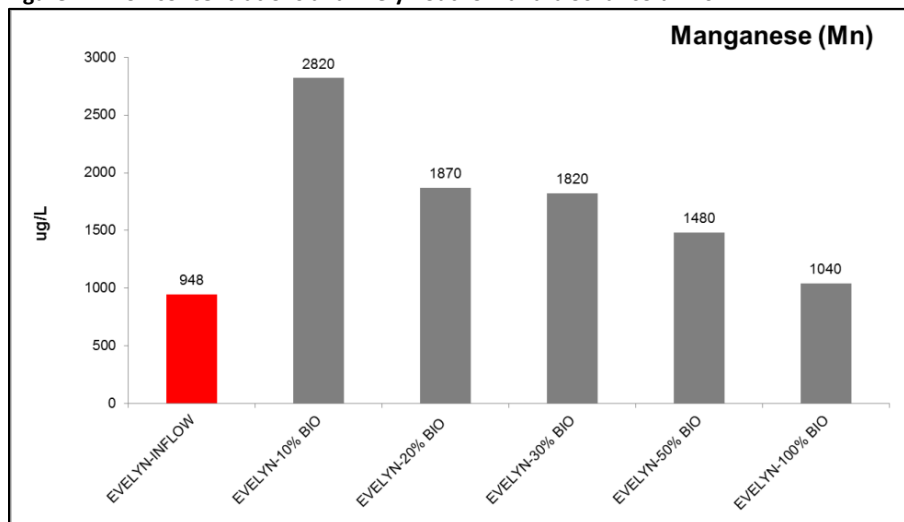


Figure 72. Manganese concentrations in effluent waters.

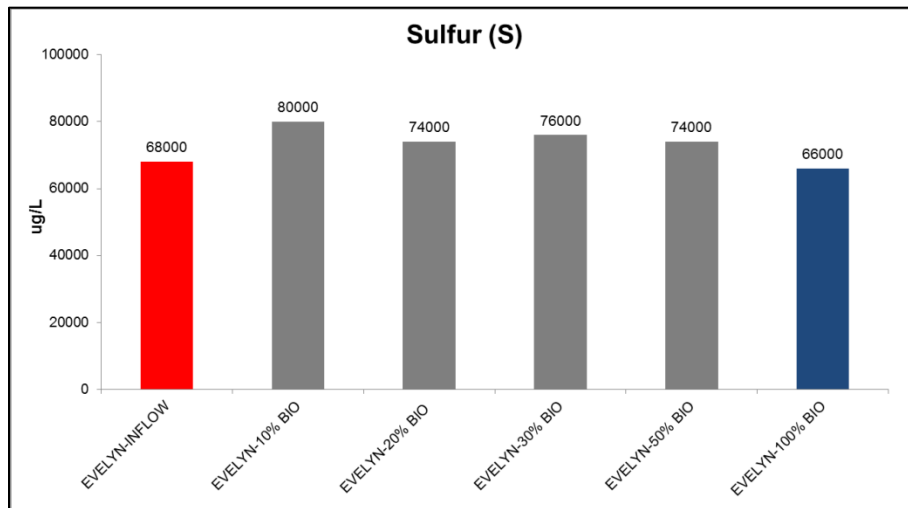


Figure 73. Sulfur concentrations in effluent waters and biochar columns.

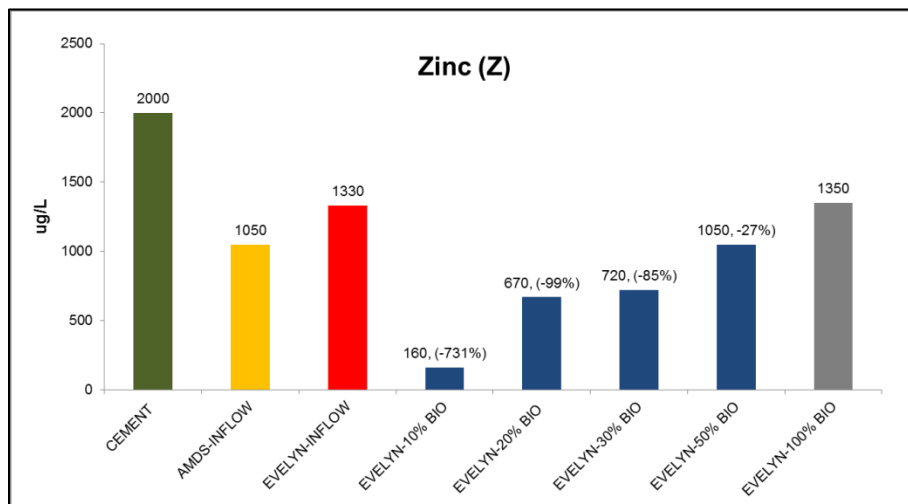


Figure 74. Total Zinc concentrations in treatment biochar columns, and Cement Creek standard (green).



Peltz 2012. Biochar Data Summary 2011

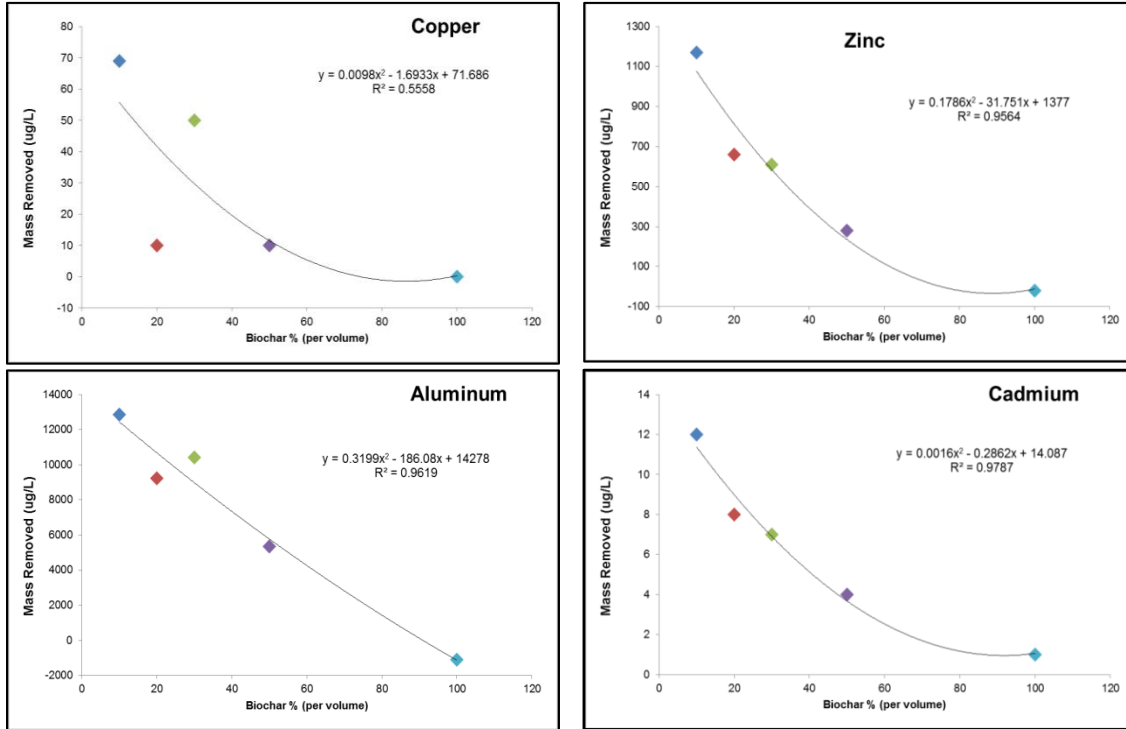


Figure 75. Mass of analytes removed after passing through biochar and ZI treatment media.

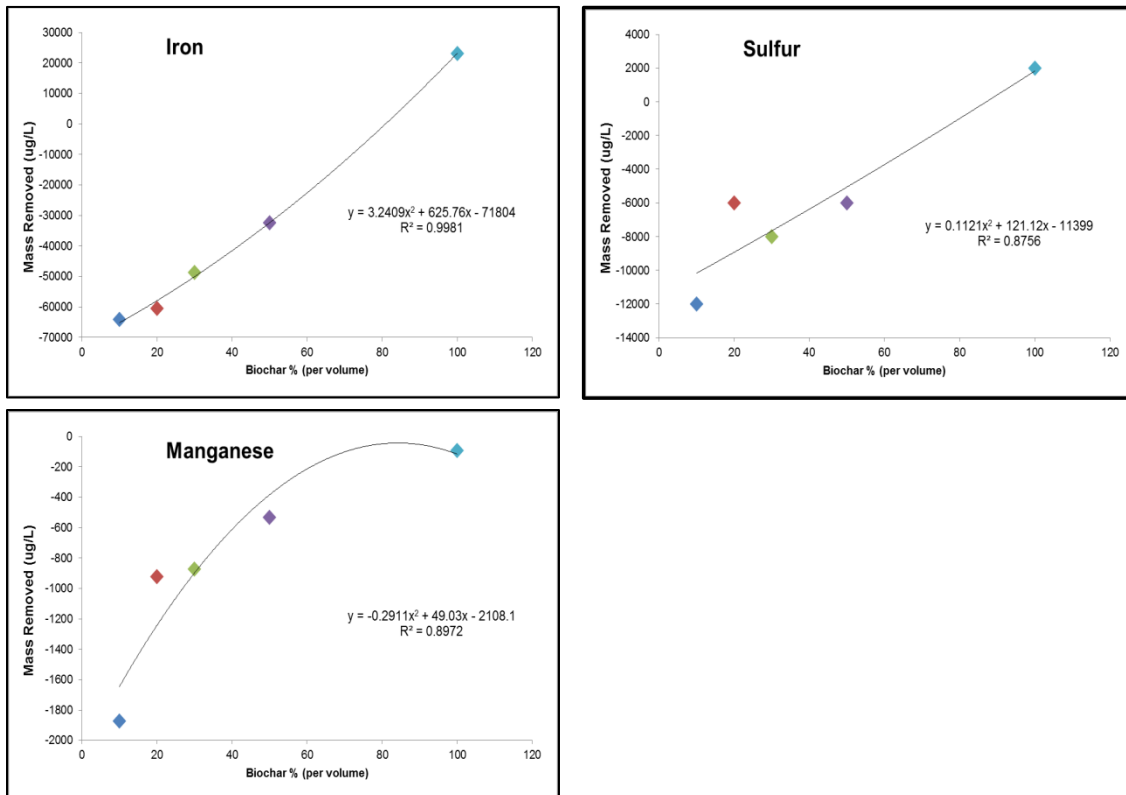


Figure 76. Mass removed of selected analytes after passing through treatment media.



Figure 77. Formation of iron ferricrete from AMD water.

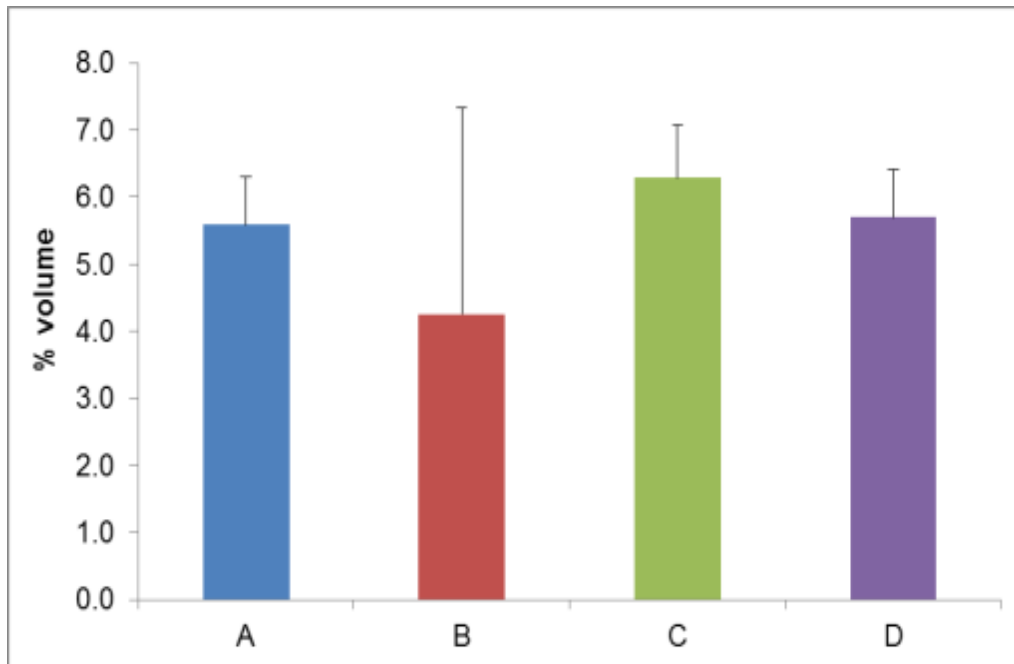


Figure 78. Mean carbon content of the first six inches of soil, bars 1 SEM.

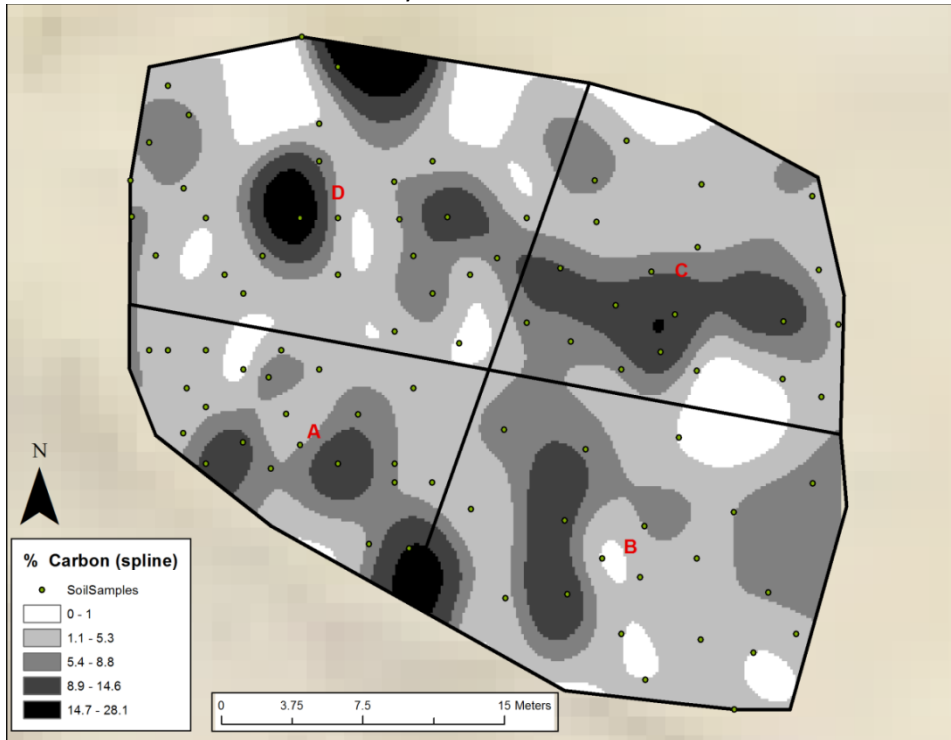


Figure 79. Predicted carbon volumes (%) at the Joe John site using a spline fit interpolation technique

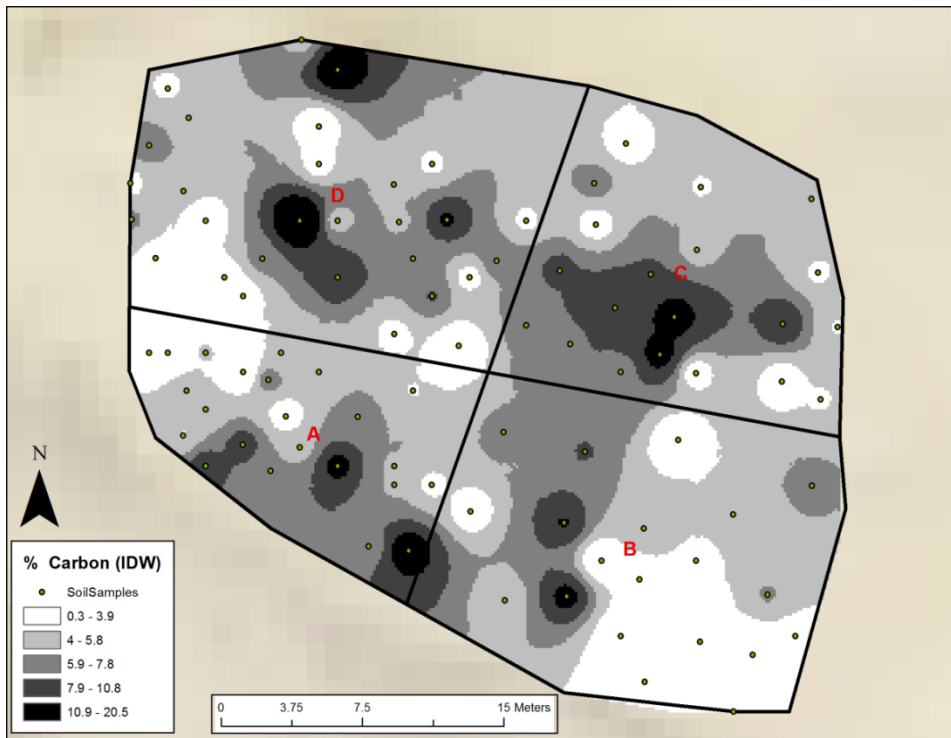


Figure 80. Predicted carbon volumes (%) at the Joe John site using an inverse distance weighting technique.

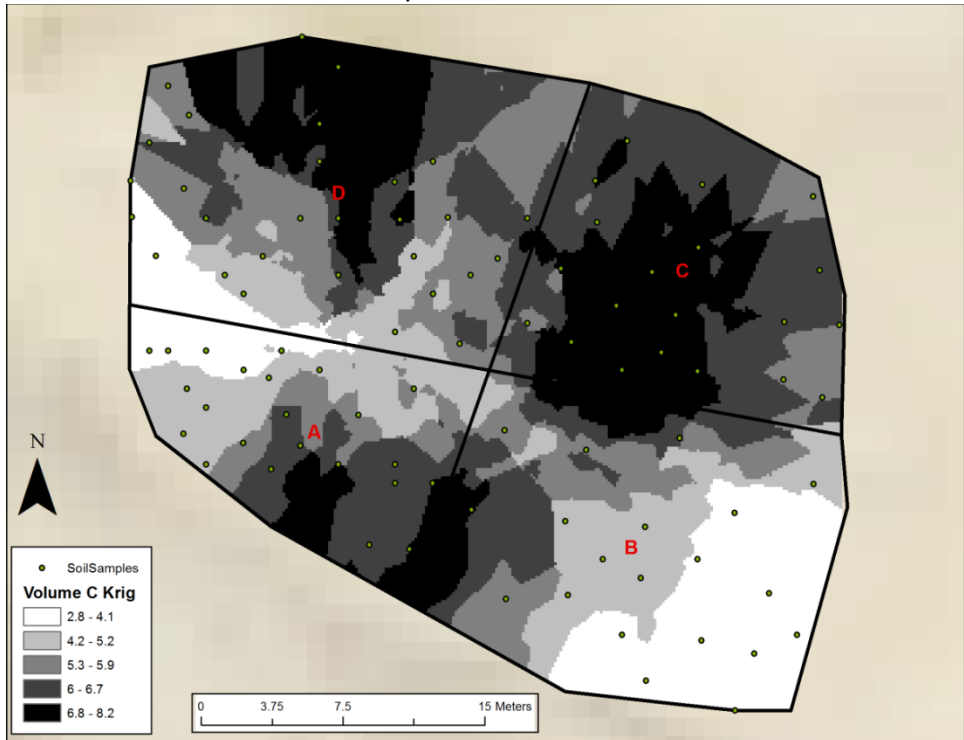


Figure 81. Predicted carbon volumes (%) at the Joe John site using an ordinary kriging technique.

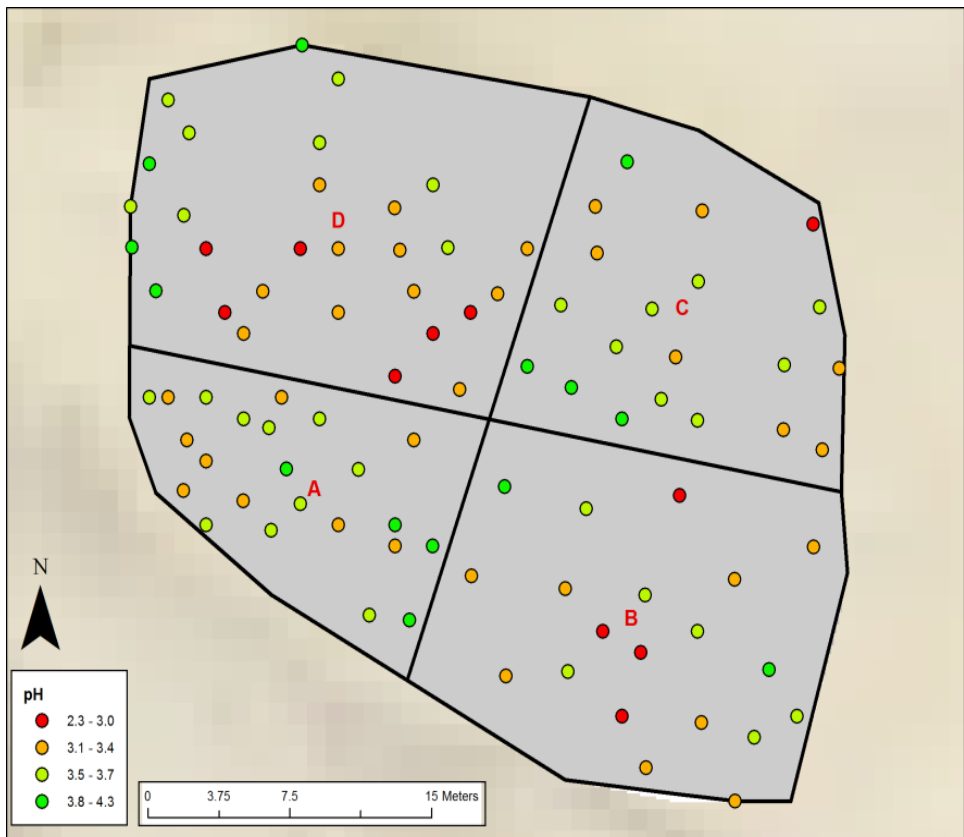


Figure 82. Soil pH of collected samples.

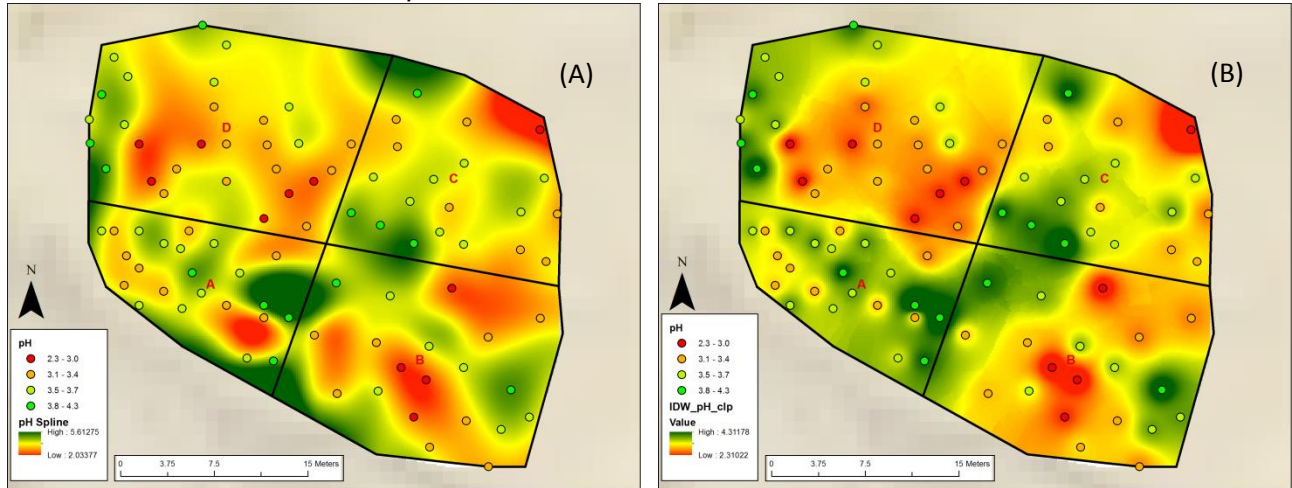


Figure 83. Interpolated soil pH by spline (A) and inverse distance weighting (B).

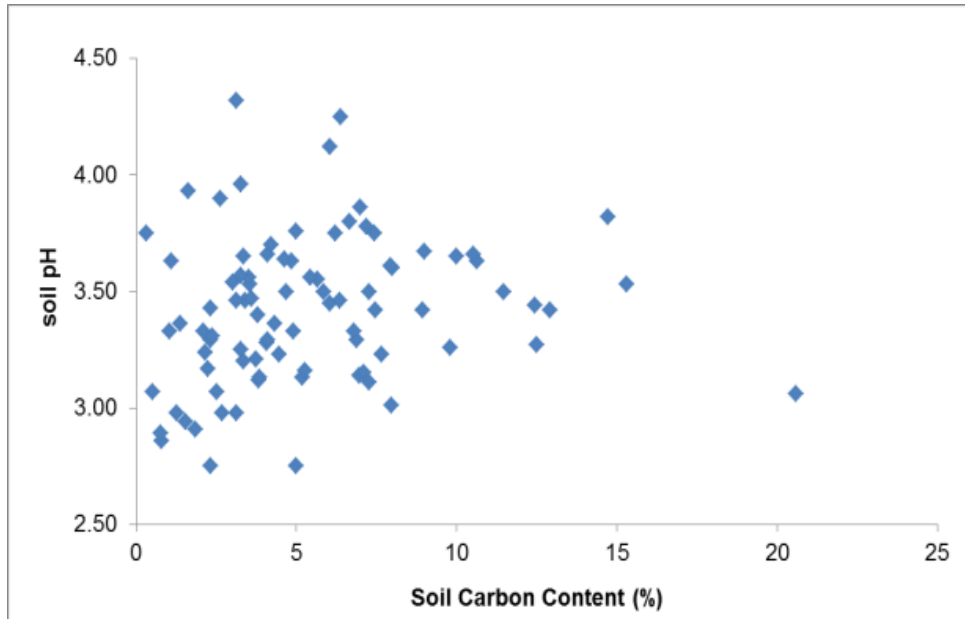


Figure 84. Relationship of measured soil carbon and soil pH.



Figure 85. USGS laboratory set-up for soil column experiments.



Figure 86. USGS column preparation.

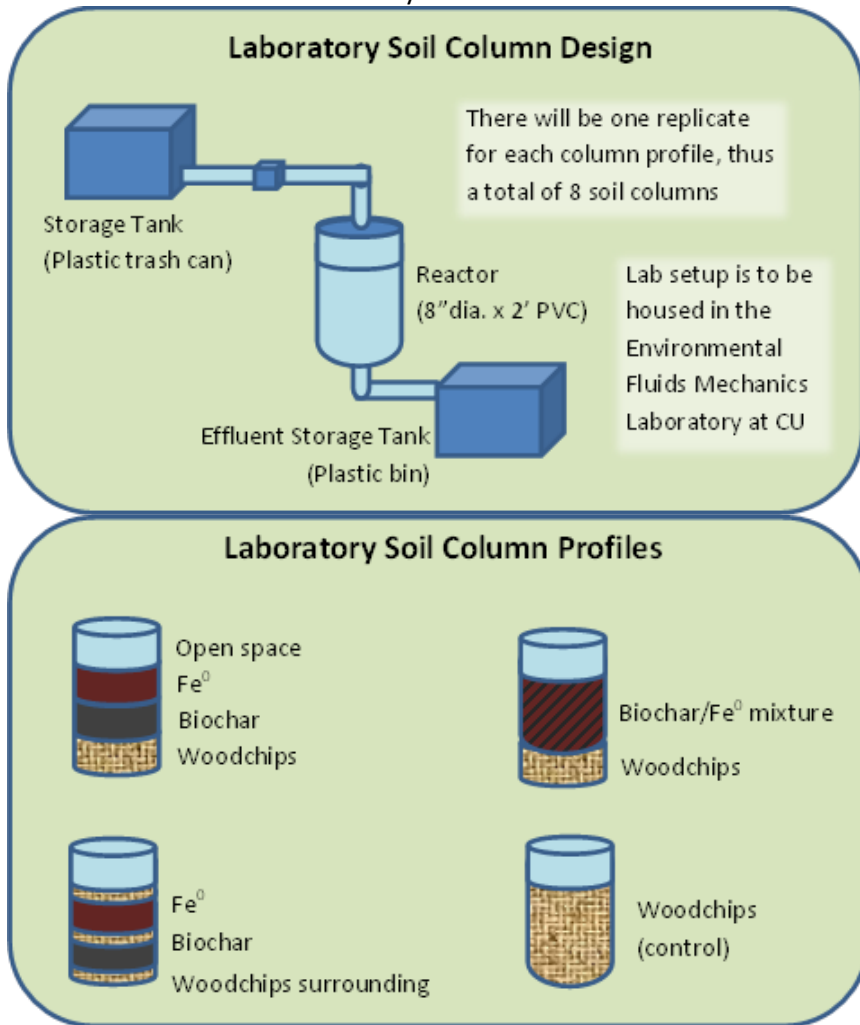


Figure 87. Laboratory design for Doug Winter AMD Treatment Cells.



Peltz 2012. Biochar Data Summary 2011

**Table 1. Climate statistics for Silverton, CO (1907-2005)**

Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	34	36.6	40.6	47.3	57.6	67.9	73.1	70.5	64.7	55.1	43.2	35.1	52.2
Average Min. Temperature (F)	-1.9	1	8.1	18.5	26.4	31.9	37.9	37.2	30.3	22	9.5	0.2	18.4
Average Total Precipitation (in.)	1.68	1.75	2.3	1.72	1.46	1.39	2.72	3.1	2.81	2.34	1.49	1.73	24.5
Average Total SnowFall (in.)	25.8	25.3	28.4	17.3	4.3	0.3	0	0	0.9	8.5	20	24	154.8
Average Snow Depth (in.)	21	27	26	11	0	0	0	0	0	1	4	12	9

**Table 2. Biochar Study Sites in the Upper Animas Basin**

Site	Elevation (m)	Latitude	Longitude	Site Type
<b>Bonner</b>	3125	4191873	259168	Waste Rock
<b>Lackawanna</b>	2840	4188537	266516	Mill Tailings
<b>Highland Mary</b>	3178	4184944	272640	Mill Tailings
<b>Joe John</b>	3473	4197107	264291	Mineral Soil
<b>Little Molas</b>	3305	4180779	261132	Forest Soil
<b>Brooklyn</b>	3460	4193850	261090	Mill Tailings
<b>Across from Bonner</b>	3253	4192699	259086	Waste Rock
<b>Road Cut</b>	2875	4188878	262516	Mineral Soil
<b>Red and Bonita</b>	3328	4198065	267446	Waste Rock
<b>Eveline</b>	3236	4196342	264960	Draining Adit

**Table 3. Seed type and rate applied for 2010 field and container trials.**

Seed Type	Genus species	% of mix	Lbs/acre
Total seed applied (acre)		100	447
Annual Rye	<i>Lolium spp.</i>	16	71
Mountain Brome	<i>Bromus marginatus</i>	36	161
Slender Wheatgrass	<i>Elymus trachycaulus</i>	19	85
Spring Wheat	<i>Triticum spp.</i>	27	121
Other		2	9

**Table 4. Seed mix used in 2011 field and container trials.**

Seed Type	Genus species	% of mix	Lbs/acre
Slender Wheatgrass	<i>Elymus trachycaulus</i>	20	89
Mountain Brome	<i>Bromus marginatus</i>	20	89
Tufted Hairgrass	<i>Deschampsia cespitosa</i>	15	67
Sheep Fescue	<i>Festuca ovina</i>	12.5	56
Alpine Bluegrass	<i>Poa alpina</i>	10	45
Mountain Lupine	<i>Lupinus pusillus</i>	10	45
Rocky Mountain Penstemon	<i>Penstemon strictus</i>	7.5	33.5
Mutton Grass	<i>Poa fendleriana</i>	5	22.4





**Table 5. Biochar calculation estimates for the Joe John Site.**

Quadrant	Area (m <sup>2</sup> )	Lbs. of Biochar	% goal	Estimate from volume/Lbs.	Lbs./m <sup>2</sup> From Density Separation
A	172	1000	20	29%	5.8
B	315	900	10	14%	2.9
C	240	900	10	19%	3.8
D	343	1600	20	23%	4.7

**Table 6. Soil Chemistry (ppm) at the Brooklyn site measured by X-Ray Reflectance in 2009**

Ni	Fe	Pb	Mn	Zr	Sr	Co	Mo	Rb	pH
211,200	35,875	1,908	3,410	193	118	1,320	35	246	5.17-5.79

**Table 7. Eveline draining adit water chemistry (mg/L) 2011**

Al	Cd	Cu	Fe	Mn	S	Zn
12.9	0.021	0.07	29.5	0.948	68	1.33

**Table 8. Eveline water chemistry as measured by Ford, Fleming, and Odell (2007)**

Flow (gpm)	pH	Al	Cd	Cu	Fe	Zn
7.65	3.22	9.43	0.014	0.078	25.17	1.05

**Table 9. Biochar production values - from BSI**

Input Item	Quantity	Unit	24 hr Total	Comments
Woodchips	1.5	Cubic Yards/hour	36	At or below 25% moisture with 10% moisture range being ideal
Woodchips	467	lbs/hr	11200	At or below 25% moisture with 10% moisture range being ideal
Electric	10	kW	240	The reaction is exothermic but the electric is used to move the chip, char, and gas
Propane	0.25	lbs/hr	1	Propane is only needed for start up or gas clean up and not used regularly in operation
Output Item	Quantity	Unit	24 hr Total	Comments
Biochar Chip	0.25	Cubic Yards/hr	6	Biochar production ranges from 40 lbs/hr to 120 lbs/hr, the most common output range at our facility is between 65 and 90 lbs/hour of operation. Over a 24 hour period that would be 1560lbs/24 hours to 2160lbs/24 hours.
Biochar Dust	0.03125	Cubic Yards/hr	0.75	
Biochar Chip	60	lbs/hr	1440	
Biochar Dust	18.75	lbs/hr	450	
Total Mass			1890	
Total Volume			6.75	
Total Bulk Density			280	LBS/Cubic Yard
Produced Gas	1.8	MMBTU		

Unit listed applies to full row where the left side column is per hour and the right side column is per 24 hours. Both mass and volume are listed for ease of use this is not intended to imply double production. It is important to understand that our product is generally lower bulk density than other products and will provide more biochar coverage per unit weight than most other products available.

**Table 10. Soil amendment sites and actions taken in 2011.**

Site	Cover Estimates	VWC Measured	Soil Collected	New Plots/Trials Established	Mine Remediation (MR)/ Water Quality (WQ)
Bonner	x	x	x	x	SA, WQ
Highland Mary	x	x	x		SA
Joe and John (Lark)	x	x	x	x	SA
Little Molas Camp	x	x			SA
Brooklyn			x	x	SA
Road Cut			x	x	SA
Across from Bonner			x	X	SA



Evelyn Draining Adit								WQ
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**Table 11. Average soil leachate concentration (ppm).**

Analyte	Bonner		Highland Mary		Joe John		Lackawanna	
	BIOCHAR	SOIL	BIOCHAR	SOIL	BIOCHAR	SOIL	BIOCHAR	SOIL
Ag	0.04	0.06	0.2	0.3			<b>0.01</b>	
Al	4.7	7.8	9.3	17.3	3.1	1.8	<b>7.0</b>	6.9
As	0.1	0.2	0.1	0.2	0.01		<b>0.05</b>	0.04
Cd	<b>0.04</b>	0.02	0.02	0.04			0.1	0.1
Cu	0.3	0.2	0.8	1.8	0.1	0.1	<b>1.24</b>	0.8
Fe	33.1	62.1	36.8	75.6	<b>7.9</b>	4.2	<b>15.4</b>	14.9
Mg	3.9	4.5	3.0	6.3	1.1	0.7	<b>6.7</b>	5.1
Mn	<b>1.3</b>	0.7	3.8	7.7	0.2	0.3	<b>5.0</b>	4.1
Ni	0.03	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Pb	1.8	3.0	4.2	8.8	<b>0.3</b>	0.2	<b>3.3</b>	2.0
Zn	<b>6.8</b>	3.3	2.2	3.8	0.1	0.2	<b>20.4</b>	16.3

**Table 12. Average soil leachate pH for biochar treatments at multiple intervals.**

Treatment	Dates of 100 ml irrigation application					
	1/19	1/24	1/31	2/6	2/20	2/27
Bio 0%	4.9	4.9	5.0	5.8	6.0	6.0
Bio 10%	5.9	5.8	5.8	6.1	6.3	6.0
Bio 20%	6.1	6.2	6.0	6.4	6.2	6.4
Bio 30%	6.2	6.4	6.3	6.5	6.6	6.6

## Soil Moisture

**Table 13. One way ANOVA for field VWC (%) by biochar and non-biochar treatments.**

Treatment	N	Median	25%	75%
Biochar	415	14.0	8.0	23.2
Non-Biochar	575	6.0	3.4	10.0

**Table 14. One way ANOVA table for field VWC (%) in 2010 and 2011 by treatment.**

Year	Treatment	N	Median	25%	75%
2010	Biochar	309	13.0	7.0	24.0
	Non-Biochar	435	6.0	3.0	11.0
2011	Biochar	106	16.2	9.8	22.9
	Non-Biochar	140	6.3	4.8	8.9

**Table 15. Least square means for field VWC (%) by year and treatment (SEM - standard error of mean).**

Year	Treatment	Mean	SEM
2010	Bio30	18.8	0.87
	BioMulch	17.8	0.86
	NCTL	8.2	0.86
	Mulch	7.9	0.96
	SCTL	7.6	0.86
2011	Bio30	19.4	1.5
	BioMulch	18.5	1.5
	NCTL	7.3	1.8
	Mulch	6.9	1.5
	SCTL	7.6	1.5

**Table 16. One way ANOVA for VWC (%) in 2010 container trials.**

Treatment	N	Median	25%	75%
Biochar	450	32	22	44
Non-Biochar	439	16	11	22

**Table 17. One way ANOVA table for 2010 container VWC (%) by treatment.**

Treatment	N	Median	25%	75%
Bio30	232	35.0	23.0	48.0
BioMulch	218	29.0	20.0	39.0
Mulch	215	16.0	10.0	23.0
SCTL	224	16.0	12.0	22.0

**Table 18. LS means for 2010 container VWC (%), SEM - standard error of the mean.**

Site Type	Treatment	Mean	SEM
Mine	Bio30	38.2	1.1
	BioMulch	31.1	1.2
	Mulch	18.3	1.2
	SCTL	18.0	1.2
Non-Mine	Bio30	32.2	1.8
	BioMulch	35.7	2.0
	Mulch	17.5	1.9
	SCTL	18.9	1.8
Acid	Bio30	42.8	1.3
	BioMulch	32.4	1.3
	Mulch	20.6	1.4
	SCTL	20.2	1.3
Non-Acid	Bio30	30.2	1.4
	BioMulch	32.0	1.4
	Mulch	15.4	1.4
	SCTL	15.9	1.4

**Table 19. Average soil VWC (%) and total precipitation (m) measured weekly from 6-30 to 8-26 at Joe John and Highland Mary.**

Date	Total Precipitation (mm) between measurements	Average VWC (%)				
		Bio30	BioMulch	Mulch	NSCTL	SCTL
6/30	10	11.6	16.4	5.5	4.4	5.1
7/1	10	25.5	19.5	9.1	9.5	10.5
7/15	52	11.2	17.6	5.3	5.8	5.4
7/22	24	17.2	18.1	7.3	8.7	7.6
7/29	31	23.6	24.8	8.8	9.9	8.5
8/5	11	29.0	14.2	8.2	8.9	12.1
8/15	0	13.9	15.0	5.4	5.9	5.8
8/22	22	15.4	15.1	5.1	5.1	5.3
8/26	8	30.9	26.5	7.7	16.9	11.2



Peltz 2012. Biochar Data Summary 2011

### Vegetation Cover

**Table 20. Pooled cover for all plots in 2010 and 2011.**

Group	N	Median	25%	75%
2010	69	26.7	13.3	45.0
2011	37	8.3	3.0	18.0

**Table 21. 2010 and 2011 vegetation cover at Bonner, Highland Mary, and Little Molas.**

Year	Year	Mean Cover (%)
Bonner	2010	30.5
	2011	3.7
Highland Mary	2010	27.4
	2011	13.3
Little Molas	2010	30.7
	2011	18.1

**Table 22. 2010 and 2011 vegetation cover (%) for field plots by treatment.**

Year	Treatment	N	Median	25%	75%
2010	Bio30	25	26.7	11.7	40.8
	BioMulch	25	36.7	13.3	60.0
	Mulch	25	20.0	7.5	48.3
	NCTL	25	0.0	0.0	0.6
	SCTL	25	15.0	2.7	42.5
2011	Bio30	26	7.5	5.0	15.0
	BioMulch	26	15.0	5.0	28.8
	Mulch	26	5.0	0.0	20.0
	NCTL	17	1.0	0.0	5.0
	SCTL	26	10.0	0.0	31.3

Peltz 2012. Biochar Data Summary 2011

**Table 23. Least squares means for field cover for 2010 and 2011 at mining and non-mining affected sites**

Year	Site Type	Treatment	Mean	SEM
2010	Mine	Bio30	24.1	3.9
		BioMulch	33.0	3.9
		NCTL	0.2	3.9
		Mulch	21.0	3.9
		SCTL	15.0	3.9
	Non-Mine	Bio30	45.6	7.1
		BioMulch	52.0	7.1
		NCTL	0.8	7.1
		Mulch	54.4	7.1
		SCTL	59.0	7.1
2011	Mine	Bio30	6.9	2.5
		BioMulch	10.8	2.5
		NCTL	1.4	3.6
		Mulch	7.7	2.5
		SCTL	10.6	2.5
	Non-Mine	Bio30	14.4	3.4
		BioMulch	34.0	3.4
		NCTL	3.2	3.4
		Mulch	14.0	3.4
		SCTL	25.2	3.4

**Table 24. Least squares means for field cover for 2010 and 2011 at acid and non-acid affected sites**

Year	Site Type	Treatment	Mean	SEM
2010	Acid	Bio30	20.7	4.5
		BioMulch	35.3	4.5
		NCTL	0.1	4.5
		Mulch	10.2	4.5
		SCTL	6.0	4.5
	Non-Acid	Bio30	38.5	4.7
		BioMulch	39.7	4.7
		NCTL	0.6	4.7
		Mulch	49.0	4.7
		SCTL	46.3	4.7
2011	Acid	Bio30	14.1	3.5
		BioMulch	25.0	3.5
		NCTL	0.1	4.6
		Mulch	6.1	3.5
		SCTL	3.5	3.5
	Non-Acid	Bio30	23.0	3.1
		BioMulch	30.2	3.1
		NCTL	1.6	3.1
		Mulch	29.1	3.1
		SCTL	33.2	3.1

## Above Ground Biomass

**Table 25. Above ground biomass (g) for all biochar and non-biochar treatments for 2010 container trials.**

Treatment	N	Median	25%	75%
Bio	56	4.1	3.3	4.8
Non-Bio	47	2.9	1.6	4.6

**Table 26. Median and Interquartile range for above ground biomass (g) by treatment for the 2010 container trials**

Treatment	N	Median	25%	75%
Biochar (30%)	28	3.7	2.9	4.6
Bio-Mulch	28	4.3	3.7	4.9
Mulch	27	3.1	2.8	4.8
Seed Only	27	1.8	0.8	3.8

**Table 27. Average above ground dried biomass (1 SD) by treatment and site.**

Site	N	Biochar	Bio-Mulch	Mulch	Seed Only
Bonner	9.0	3.2 (0.8)	4.0 (0.7)	2.7 (0.6)	1.0 (0.7)
Highland Mary	6.0	4.5 (0.9)	4.7 (0.9)	3.9 (1.7)	4.3 (1.2)
Joe John	3.0	2.8 (0.6)	3.1 (0.8)	1.9 (0.4)	1.1 (0.6)
Lackawanna	3.0	3.1 (1.0)	4.3 (0.6)	5.3 (1.3)	1.1 (0.9)

**Table 28. Above ground biomass (g) for container trials, grouped by mining and acid sites.**

Site Type	Treatment	Mean	SEM
Mine	Bio30	3.5	0.26
	BioMulch	4.1	0.26
	Mulch	3.4	0.27
	SCTL	1.9	0.27
Non-Mine	Bio30	4.1	0.45
	BioMulch	4.9	0.45
	Mulch	4.6	0.45
	SCTL	3.6	0.45
Acid	Bio30	3.1	0.25
	BioMulch	3.9	0.25
	Mulch	3.1	0.26
	SCTL	1.1	0.25
Non-Acid	Bio30	4.3	0.27
	BioMulch	4.8	0.27
	Mulch	4.3	0.27
	SCTL	3.9	0.28

## Vegetation Height

**Table 29. Average vegetation heights (mm) measured at weekly intervals for each biochar treatment and soil control.**

Treatment	Date								
	1-19	1-24	1-31	2-6	2-14	2-20	2-27	3-12	3-28
Soil	1.3	9.8	15.0	21.8	24.0	24.9	24.9	26.3	30.0
Bio 10%	6.0	21.7	29.3	32.1	36.2	37.4	39.8	39.3	48.3
Bio 20%	9.5	24.5	30.7	35.8	41.7	43.8	47.4	49.8	57.6
Bio 30%	8.3	23.1	32.1	39.0	42.1	46.9	52.1	56.4	64.0

## Eveline Chemistry

**Table 30. pH measurements at the Evelyn Site in each of the biochar/ZI, and wood chip treatments.**

Treatment	Date	(# days of flow)	pH
Evelyn Portal	8-9-11	NA	3.40
Inflow (Bucket)	8-9-11	NA	3.38
100% Biochar	8-9-11	7	3.43
50% Biochar/50% ZI	8-9-11	7	3.71
30% Biochar/ 70% ZI	8-9-11	7	4.56
20% Biochar/ 80% ZI	8-9-11	7	5.36
New Tubes 8-18-11			
Evelyn Portal	8-18-11	0	3.20
Inflow (Bucket)	8-18-11	0	3.20
50% Biochar/50% ZI	8-18-11	0	6.30
30% Biochar/70% ZI	8-18-11	0	7.00
20% Biochar/80% ZI	8-18-11	0	6.70
Tube (no treatment)	8-18-11	0	3.42
Evelyn Portal	9-1-11	NA	3.31
Inflow (Bucket)	9-1-11	NA	3.25
50% Biochar/50% ZI	9-1-11	14	NA**
30% Biochar/ 70% ZI	9-1-11	14	NA**
20% Biochar/ 80% ZI	9-1-11	14	6.01
20% Wood Chips/80% ZI	9-1-11	14	NA**
40% Wood Chips/60% ZI	9-1-11	14	NA**

\*\* New tubes were installed on 8-18-11 with new PVC end caps; all biochar, ZI, and wood chip mixes were re-constructed on this date.

**Table 31. pH measured at Eveline concrete tank outlet.**

Time (Date)	Outflow pH
12:00 (8-18-11)	8.54
12:05	6.62
12:10	6.03
12:15	5.71
12:20	5.15
12:30	3.99
2:00 (10-10-11)	2.7





**Table 32. Metal concentrations (ug/l) from each soil column treatment following 7 days of flow.**

Analyte	Inflow	WQ Goal	Biochar additions				
			100%	50%	30%	20%	10%
Al	12,900	700	14,000	7,550*	2,480*	3,670*	40*
Cd	21	3.11	20	17	14	13	9
Cu	70	25.83	70	60	20*	60	0*
Fe	29,500	1,200	6,360	61,900	78,200	51,100	93,600
Mn	948	1000	1,040	1,480	1,820	1455	2,820
Zn	1,330	730	1,350	1,050	720*	340*	160*
pH**	3.2-3.4	5.3	3.43	3.71	4.56	5.36*	6.10*

**Joe John**

**Table 33. Seed mix used at the Joe John Repository.**

Type	Common	Genus	Weight (%)
Wheat	Slender Wheatgrass	<i>Elymus trachycaulus</i>	20
Brome	Mountain Brome	<i>Bromus marginatus</i>	20
Grass	Tufted Hairgrass	<i>Deschampsia cespitosa</i>	15
Fescue	Sheep Fescue	<i>Festuca ovina</i>	12.5
Grass	Alpine Bluegrass	<i>Poa alpina</i>	10
Forb	Mountain Lupine	<i>Lupinus pusillus</i>	10
Forb	Rocky Mountain penstemon	<i>Penstemon strictus</i>	7.5
Grass	Mutton Grass	<i>Poa fendleriana</i>	5

**Table 34. Joe John biochar application amounts.**

Quad	Area (m <sup>2</sup> )	Biochar (lbs.)	Lbs./m <sup>2</sup>	Application Rate Goal	Estimate from Volume/Lbs.
A	172	1000	5.8	20	29%
B	315	900	2.9	10	14%
C	240	900	3.8	10	19%
D	343	1600	4.7	20	23%

**Table 35. Joe John average and maximum carbon % by volume for collected soil cores.**

Quad	Mean Volume (%)	Max Volume (%)
A	5.6	14.7
B	4.3	12.4
C	6.3	13.4
D	5.7	20.6