Evaluation of Reclamation Efforts from Pipeline Right of Way Construction Using the Cornell Soil Health Test

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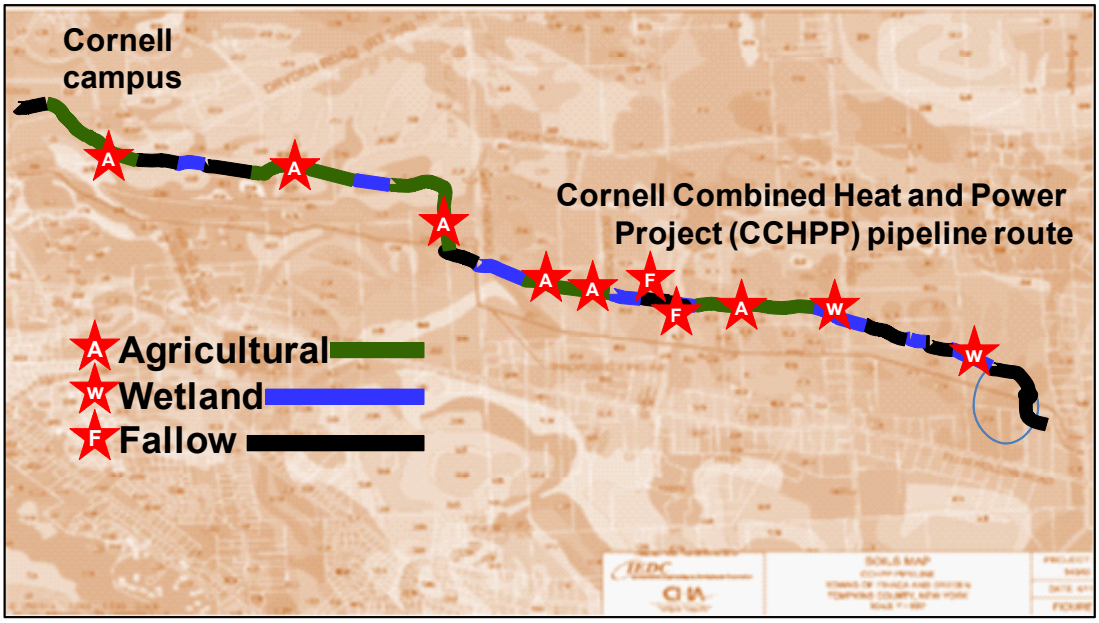
Background

Pipeline construction projects are expected to greatly expand in parts of New York as a result of the exploration of the Marcellus Shale natural gas field. Right-of-way (ROW) construction efforts can result in damage to soil quality along its course from construction activities like soil removal, compaction by heavy equipment, mixing of topsoil and subsoil materials, etc., thereby affecting the ability of the disturbed soils to sustain soil functions like plant growth, water infiltration and retention, support of soil life, etc. Soil quality sampling to monitor and assess the impact of construction can ensure that applied construction standards are adequate and/ or suggest a focus for remediation efforts.

The newly-developed Cornell Soil Health Test (CSHT) (*How to Interpret and Use the Cornell Soil Health Test Report, What's Cropping Up?, Vol. 18, No. 1, 2008*) provides a standard for assessment of soil quality relative to important soil physical, chemical and biological processes and functions. The CSHT was evaluated as a tool for assessment of right-of-way (ROW) construction impacts using a test case of the Cornell Combined Heat and Power Project, which included the construction of an eight-inch gas delivery line over a three mile length from the interstate transmission line to the Cornell campus during 2008 and 2009. Site-specific information is needed to provide meaningful quantitative assessment of the effects of construction activities on soil quality. Soil samples were collected from areas crossed by the pipeline (Figure 1) including Wetlands, Agricultural lands and Fallow areas, each having different construction guidelines, in a paired sampling scheme (on- and off- right of way).

Right-of-Way Construction Projects must conform to standards and practices that minimize adverse effects on agricultural and other land use types. These standards and practices that apply to each project from planning, through construction, restoration and post-construction monitoring and rehabilitation are documented in the Environmental Management and Construction Standards and Practices (EM&CS&P) plan. Land areas crossed that are designated as Fallow land use areas require the basic soil restoration efforts. Where the pipeline crosses Agricultural land, the developed EM&CS&P plan has provision for additional site-specific soil management standards. Wetland areas crossed by the project also require enhanced construction and reclamation standards, as found in Section 11 of the EM&CS&P plan. Table 1 lists the applied Soil Management for the different land use types.

Figure 1. Soils map with land use type and soil health assessment sampling sites (June 2009)



Post-Construction ROW Soil Health Assessment

Fall 2008 saw most of the pipe buried and the soil surface restored. Where ephemeral streams and ditches existed, conservation measures using straw bales and silt curtains effectively prevented the washing out or silting in of waterways. Grass seed and mulch were broadcast in the Fall of 2008 across the Wetland and Fallow land use areas as the heavy equipment project work was effectively completed by this time.

Soil Health

Table 1. Applied pipeline ROW construction and restoration practices by land use type.

Soil Management Practice	Land Use Type		
	Wetland	Agricultural Land	Fallow Land
Install pipe. Replace subsoil from trench onto pipe. Rough grade and remove large stones. Apply lime and fertilizer. Disk harrow.	X	X	X
Rubber or wooden mats to avoid compaction. Segregate topsoil and trench spoil on top of mats. Remove mats in reverse order.	X		
Strip and stockpile topsoil. Deep rip after rough grading of subsoil. Replace topsoil. Rough grade and deep rip again.		X	
Broadcast grass seed and apply straw mulch.	X		X
Drill grass seed and apply straw mulch.		X	

Soil Health samples were collected from the pipeline construction area in June, 2009. Sampling sites were chosen to capture typical characteristics of each soil mapping unit encountered – Agricultural, Wetland, and Fallow. Composite soil samples were collected from locations directly on the ROW and just off the ROW in the adjacent undisturbed land area. Each location therefore has paired samples from within the disturbed area (directly ON the ROW) and an associated "benchmark" sample of native soil conditions collected from directly outside the construction area (OFF the ROW). Comparison of collected data from the paired locations allows for immediate quantitative evaluation of the effects of construction on native soil function and the efficacy of the varying construction practices and remediation techniques applied to the different land use types. The field constructions photos in Figure 2 show the typical construction site appearance by land use type.

The measured suite of CSHT indicators can be used to define and assess ROW construction project effects on the land it traverses. Assessing soil function through measuring a suite of indicators that represent critical soil processes allows for the quantification of the success of remediation efforts, identification of remaining soil limitations, and guidance for additional remedial practices if post-construction reclamation was inadequate. A composite soil health score is used to document overall soil quality status at the time of sampling. Repeated sampling in time can be used to measure the effectiveness of applied project remedial practices.

Construction Effects on Soil Health

The effects of the ROW construction can be evaluated by comparing results from the on and off-ROW Soil Health Reports (Figures 3-5). Cornell Soil Health Test results indicated that (i) Wetland and Agricultural land construction

Figure 2. In-field construction site soil management practices by land use type.

Soil Health

CORNELL SOIL HEALTH TEST REPORT (COMPREHENSIVE)

ON Right of Way AGRICULTURAL

	Indicators	Value	Rating	Constraint
PHYSICAL	Aggregate Stability (%)	72	97	
	Available Water Capacity (m/m)	0.17	54	
	Surface Hardness (psi)	70	89	
	Subsurface Hardness (psi)	320	38	
BIOLOGICAL	Organic Matter (%)	6.4	99	
	Active Carbon (ppm) [Permanganate Oxidizable]	695	67	
	Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week)	22.9	100	
	Root Health Rating (1-9)	6.0	38	
CHEMICAL	*pH	5.8	44	
	*Extractable Phosphorus (ppm) [Value <3.5 or >21.5 are downscored]	25.0	44	
	*Extractable Potassium (ppm)	185	100	
	*Minor Elements		100	
OVERALL QUALITY SCORE (OUT OF 100):			72.5	High

Measured Soil Textural Class:==> silt loam
SAND (%): 21.8 SILT (%): 68.1 CLAY (%): 10.1

Location (GPS): Latitude=> 42.43539143 Longitude=> -76.44353276

LTH TEST REPORT (COMPREHENSIVE)

OFF Right of Way AGRICULTURAL

Value	Rating	Constraint
98	100	
0.16	50	
105	79	
350	27	Subsurface Pan/Deep Compaction
6.4	99	
691	66	
16.7	100	
4.0	63	
5.4	0	Toxicity, Nutrient Availability (for crop specific guide, see CNAL report)
8.0	100	
145	100	
	56	
UT OF 100):	70.0	Medium

silt loam
23.8 SILT (%): 67.1 CLAY (%): 9.1

3526537 Longitude=> -76.44351365

Figure 3. Cornell Soil Health Test Reports from ON- and OFF- pipeline Right of Way. AGRICULTURAL land use type. Pipeline construction and restoration efforts decreased subsurface compaction and also increased soil pH.

CORNELL SOIL HEALTH TEST REPORT (COMPREHENSIVE)

ON Right of Way WETLAND

	Indicators	Value	Rating	Constraint
PHYSICAL	Aggregate Stability (%)	65	94	
	Available Water Capacity (m/m)	0.18	66	
	Surface Hardness (psi)	95	82	
	Subsurface Hardness (psi)	180	88	
BIOLOGICAL	Organic Matter (%)	3.4	47	
	Active Carbon (ppm) [Permanganate Oxidizable]	439	18	Soil Biological Activity
	Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week)	19.8	100	
	Root Health Rating (1-9)	3.0	75	
CHEMICAL	*pH	6.1	67	
	*Extractable Phosphorus (ppm) [Value <3.5 or >21.5 are downscored]	2.0	44	
	*Extractable Potassium (ppm)	100	100	
	*Minor Elements		56	
OVERALL QUALITY SCORE (OUT OF 100):			69.7	Medium

Measured Soil Textural Class:==> silt loam
SAND (%): 35.2 SILT (%): 52.9 CLAY (%): 12.0

Location (GPS): Latitude=> 42.43250219 Longitude=> -76.4198875

LTH TEST REPORT (COMPREHENSIV

OFF Right of Way WETLAND

Value	Rating	Constraint
83	99	
0.19	71	
140	65	
290	50	
4.1	67	
504	28	Soil Biological Activity
15.4	100	
4.0	63	
5.3	0	Toxicity, Nutrient Availabili crop specific guide, see CNA
2.0	44	
95	100	
	56	
UT OF 100):	62.0	Medium

silt loam
31.6 SILT (%): 61.8 CLAY (%): 6.

3242801 Longitude=> -76.41997509

Figure 4. Cornell Soil Health Test Reports from ON- and OFF- pipeline Right of Way. WETLAND land use type. Pipeline construction and restoration efforts increased soil pH.

CORNELL SOIL HEALTH TEST REPORT (COMPREHENSIVE)

ON Right of Way FALLOW

	Indicators	Value	Rating	Constraint
PHYSICAL	Aggregate Stability (%)	27	35	
	Available Water Capacity (m/m)	0.13	28	water retention
	Surface Hardness (psi)	375	1	rooting, water transmission
	Subsurface Hardness (psi)	450	5	Subsurface Pan/Deep Compaction
BIOLOGICAL	Organic Matter (%)	2.5	22	energy storage, C sequestration, water retention
	Active Carbon (ppm) [Permanganate Oxidizable]	509	29	Soil Biological Activity
	Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week)	5.2	0	N Supply Capacity
	Root Health Rating (1-9)	3.0	75	
CHEMICAL	*pH	7.5	67	
	*Extractable Phosphorus (ppm) [Value <3.5 or >21.5 are downscored]	2.0	44	
	*Extractable Potassium (ppm)	65	100	
	*Minor Elements		56	
	OVERALL QUALITY SCORE (OUT OF 100):		38.5	Very Low

Measured Soil Textural Class:==> silt loam

SAND (%): 37.3 SILT (%): 54.3 CLAY (%): 8.4

Location (GPS): Latitude=> 42.4347705 Longitude=> -76.43774598

LTH TEST REPORT (COMPREHENSIVE)

OFF Right of Way FALLOW

Value	Rating	Constraint
90	100	
0.16	49	
263	15	rooting, water transmission
383	17	Subsurface Pan/Deep Compaction
5.0	87	
689	66	
21.6	100	
2.8	88	
5.3	0	Toxicity, Nutrient Availability (for crop specific guide, see CNAL report)
1.0	17	<3.5:Plant P Availability, >21.5: Env. Loss Potential
115	100	
	56	
UT OF 100):	57.9	Medium

silt loam

24.2 SILT (%): 68.4 CLAY (%): 7.4

3469574 Longitude=> -76.43787548

Figure 5. Cornell Soil Health Test Reports from ON- and OFF- pipeline Right of Way. FALLOW land use type. Pipeline construction and restoration efforts decreased Available Water Capacity, decreased Organic Matter, lowered soil biological activity and increased soil pH and Phosphorus. Overall Soil Quality Score decreased significantly.

and remediation methods resulted in satisfactory post-construction soil conditions, and (ii) lower construction and remediation standards in Fallow areas resulted in significantly lower soil quality levels than the other lands. In the latter case, additional remediation practices such as deep ripping and organic matter applications would address some of the measured constraints.

We conclude that the Cornell Soil Health Test is an effective tool for assessing soil quality impacts of right-of-way construction projects and should be considered as a monitoring tool in the permitting of such activities. The direct measurement of soil parameters can be used to assess compliance with construction site soil mitigation and reclamation standards. We will return to the same GPS coordinates in 2011 to sample and test on- and off- the ROW to gather information on the effects of time on soil quality.

More information on soil health testing at: http://soilhealth.cals.cornell.edu

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