Technical Memorandum

VIA EMAIL

To: Mr. Justin Jepperson – Noble Energy Inc.

From: Kelley House, CPSS – Duraroot, LLC

Date: April 25, 2019

Subject: Soil Resource Assessment and Reclamation Plan for the former Myers 14-21 Well Pad and Production Facility

---

INTRODUCTION

Duraroot, LLC (Duraroot) has prepared the following Technical Memorandum and Reclamation Plan for Noble Energy Inc. (Noble) to discuss the results of the former Myers 14-21 well pad and production facility soil resource assessment. This Technical Memorandum also provides soil preparation guidelines and amendment recommendations for improving in-situ soil resource quality for reclamation and planting efforts.

A Duraroot Certified Professional Soil Scientist (CPSS) visited the former Myers 14-21 well pad and production facility on April 5, 2019, to assess soil physicochemical properties of in-situ soil resources available for planting. The site visit also aimed to further establish any potential soil properties that may limit plant establishment and growth and reduce overall plant vigor. The Myers 14-21 well pad and production facility is located in the NE ¼ of the NW ¼ of Section 14, Township 5N, Range 65W in Weld County, Colorado, and encompasses roughly 1.1 acres (Figure 1).

SOIL SAMPLE ANALYTICAL RESULTS

Discrete soil samples were collected across the location and submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis (Figure 1; Table 1). Soil samples were collected to a depth of 8.0-inches from 18 locations (SS - 1 to SS - 18) across the former well pad and production facility location to provide a representative account of soil conditions. In addition, two (2) soil samples (SS - 19 and SS - 20) were collected from the adjacent, undisturbed field to provide inherent soil conditions.

Laboratory parameters were selected to assess the suitability of in-situ soil resources for reclamation and crop establishment. Soil analytics included saturated paste pH, electrical conductivity (EC), soluble cations – (Ca, Mg, and Na), sodium adsorption ratio (SAR), soil texture, soil organic matter content (SOM), cation exchange capacity (CEC), saturation percentage (%), soil lime ($CaCO_3$) content, and soil macro-nutrient levels (nitrogen-N, phosphorous-P, and potassium-K). The Myers 14-21 well pad and production facility soil sample analytical results are available in Table 2.

Soil pH

Soil pH is a measure of acidity and is found by measuring the hydrogen (H+) ion activity (Thorup, 1984). Soil pH is considered one of the most important measurements in the soil and is often called the "master variable" (McBride, 1994). Soil pH affects nutrient availability, ion exchange, dissolution/precipitation of minerals, redox (reduction and oxidation) reactions, adsorption, and other important factors in the soil system, which can influence plant growth and development (Thorup, 1984; McBride, 1994; et al.). Soil pH between 6.0 and 8.5 is generally optimal for alfalfa growth (USDA, NRCS. 2019). As the pH increases or decreases from this ideal range, the availability of plant nutrients may limit plant growth.

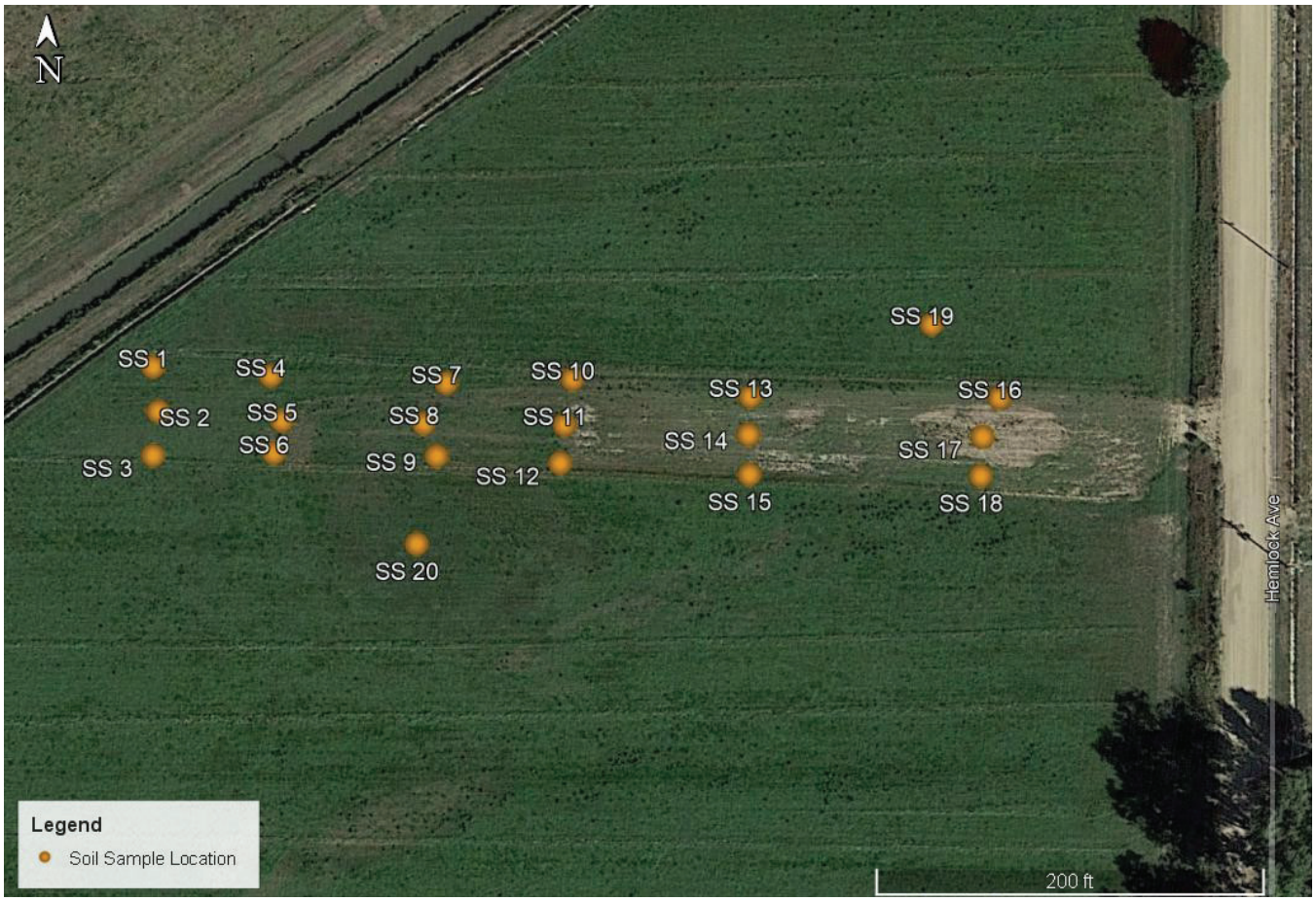

Figure 1. Aerial image of the former Myers 14-21 wellhead and production facility with soil sample locations. ***Image courtesy of Google Earth.***

Soil pH at the former Myers 14-21 well pad and production facility was found to be within suitable levels for alfalfa production and reclamation. Soil pH on the former Myers 14-21 location ranged from 7.8 to 8.2, with an average soil pH of 8.0. Soil pH in the adjacent field ranges from 8.3 to 8.4 and is higher than the former well pad location. Elevated soil pH can be managed by supplementing soil phosphorus during planting, or by incorporating an acidifying agent into the soil (i.e., elemental sulfur, sulfur containing fertilizers).

Soil Salinity

Soil EC is an estimate of soil salinity (Hanson et al., 1999) and is measured by the ECe of the saturated paste extract. At high enough levels, soil salinity can negatively impact plant growth due to osmotic stress (Hanson et al., 1999). This osmotic stress can make it difficult for plants to extract water from the soil (Bohn et al., 1985).

Soil EC in the former Myers 14-21 well pad and production facility soils is suitable for plant growth and reclamation in all sample locations. Soil EC on the former Myers 14-21 location ranges from 0.65 to 2.2-dS/m, with an average soil EC of 1.0-dS/m. Soil EC generally increases from west to east across the location. Average soil EC in the adjacent field is 0.53-dS/m. Alfalfa (*Medicago sativa*) has a moderate salinity tolerance (EC = 4.1 to 8.0-dS/m; USDA, NRCS. 2019). Soil salinity of the former Myers 14-21 well pad and production facility soils should not impair alfalfa production.

Table 1. Coordinates for individual soil samples.

Sample ID	Latitude	Longitude
SS-1	40.40454	-104.63260
SS-2	40.40448	-104.63259
SS-3	40.40441	-104.63260
SS-4	40.40453	-104.63239
SS-5	40.40446	-104.63237
SS-6	40.40442	-104.63238
SS-7	40.40452	-104.63206
SS-8	40.40446	-104.63210
SS-9	40.40441	-104.63208
SS-10	40.40452	-104.63183
SS-11	40.40446	-104.63184
SS-12	40.40440	-104.63185
SS-13	40.40450	-104.63150
SS-14	40.40444	-104.63150
SS-15	40.40439	-104.63150
SS-16	40.40450	-104.63103
SS-17	40.40444	-104.63107
SS-18	40.40439	-104.63107
SS-19	40.40460	-104.63116
SS-20	40.40429	-104.63212

Soil Sodicity

Sodic soils are "non-saline soils containing sufficient exchangeable sodium to adversely affect crop production and soil structure" (Soil Science Society of America, 2010). Elevated exchangeable sodium concentrations in the soil can negatively impact soil structure causing the soil to disperse, resulting in hard surface crusts, reduced infiltration rates, and reduced oxygen diffusion rates. The definition and standard for describing sodic soils based on soil chemistry are those soils that have a SAR greater than 13, an EC less than 4.0 dS/m, and pH between 8.5 and 10.

Soil SAR in the former Myers 14-21 well pad and production facility soils is suitable for plant growth and reclamation in all sample locations. Soil SAR on the former Myers 14-21 location ranges from 0.90 to 2.6, with an average soil SAR of 1.7. Average soil SAR in the adjacent field is identical to average SAR on-site at 1.7. Soil sodicity of the former Myers 14-21 well pad and production facility soils should not impair alfalfa production.

Soil Texture

Soil texture is determined by the relative proportions of sand, silt, and clay particles in a soil. Coarse soil textures (elevated sand content) have limited water retention capabilities and are less reactive, therefore less capable of nutrient retention. Fine soil textures (elevated clay content) provide more surface area and are therefore more reactive. Fine textured soils are more likely to become compacted or dispersed reducing infiltration and aeration, which is necessary for productive plant growth. Soils with fine soil textures are also more likely to retain soil salts due to reduced leaching capabilities. Ideal soil textures for plant growth contain a mixture of the three particle classes and are not dominated by one particular particle size.

Soil texture at the former Myers 14-21 well pad and production facility was consistent among all collected soil samples, on-site and off-site. Soil textures for the former Myers 14-21 well pad and production facility were found to consist of sandy clay loams (SCL) and sandy loams (SL). Soil texture is suitable for reclamation and alfalfa production.

Soil Organic Matter

SOM consists of plant and animal residue in the soil in various stages of decomposition and gives the A horizon its characteristic dark color (USDA-NRCS, 2015). SOM provides essential nutrients for plant growth. In addition, SOM improves soil structure and soil tilth, infiltration and aeration, and leaching of undesirable constituents.

SOM of the former Myers 14-21 well pad and production facility soils ranges from 1.6 to 4.0-percent, with an average SOM of 3.0-percent. Average SOM in the adjacent field is 3.5-percent. SOM levels of the former Myers 14-21 well pad and production facility soils are similar to adjacent levels and should not impair alfalfa production.

Soil Fertility

Soil fertility is evaluated by measuring the relative amount of plant available soil nutrients. These primarily consist of soil N-P-K levels, which make up the soil macro-nutrient component. Macro-nutrients are the soil nutrients that are required by plants in the greatest concentration and are essential for plant function and development.

Soil fertility was variable across the former Myers 14-21 well pad and production facility location. Soil N was generally found to be available at suitable levels for new alfalfa plantings. New seedings of alfalfa generally do not benefit from pre-plant Nitrogen application. Soil N levels greater than or equal to 12.0-pounds per acre NO_3 – N do not warrant N application at planting. Average soil N in the Myers 14-21 well pad and production facility soils is 17.7-pounds per acre.

Soil P is often the most limiting soil macro-nutrient in Colorado soils and is extremely important for establishing new plants as it is essential for root development. Soil P levels in the former Myers 14-21 well pad and production facility soils range from 10.0 to 141-ppm, with an average soil P concentration of of 29.5-ppm. In addition, elevated soil lime ($CaCO_3$) content may chemically "tie up" soil P in the system by forming insoluble calcium-phosphate, thus reducing P availability for plant uptake. Soil lime levels at the Myers 14-21 well pad and production facility range from 0.90 to 6.7-percent with an average lime content of 3.7-percent. Soil lime content is variable across the location and elevated in various samples. Elevated soil lime content coupled with low soil P levels in various soil samples warrant the application soil P at the time of planting.

Soil K levels are typically found to be adequate in Colorado soils. The average soil K level in the former Myers 14-21 well pad and production facility soils is 140-ppm. Soil K is suitable for alfalfa production on the former Myers 14-21 well pad and production facility.

Table 2. Soil chemical and physical data for the former Myers 14-21 well pad. Parameters shown in red may interfere with reclamation success.

Sample ID	Depth	pH	EC	SAR	Percent Saturation	Organic Matter	Lime	Sand	Silt	Clay	Texture	NO_3 - N	Mehlich-P	NH_4OAC-K
	inches		dS/m		%							lbs/acre	ppm	
SS-1	0 to 8	8.1	0.65	1.4	37	3.5	6.6	59	16	25	Sandy Clay Loam	19	23	160
SS-2	0 to 8	7.9	0.69	1.4	42	3.7	6.7	63	14	23	Sandy Clay Loam	13	19	156
SS-3	0 to 8	7.9	0.65	1.6	41	3.4	1.9	65	12	23	Sandy Clay Loam	10	17	100
SS-4	0 to 8	8.1	0.70	1.7	39	3.7	2.8	63	16	21	Sandy Clay Loam	7.0	10	66
SS-5	0 to 8	8.1	0.72	1.6	36	3.7	1.9	65	12	23	Sandy Clay Loam	17	11	78
SS-6	0 to 8	8.0	0.66	1.6	45	2.8	1.9	65	18	17	Sandy Loam	12	22	107
SS-7	0 to 8	7.9	0.83	1.6	40	4.0	5.7	64	15	21	Sandy Clay Loam	11	42	158
SS-8	0 to 8	8.0	1.0	1.8	42	3.6	5.9	62	17	21	Sandy Clay Loam	22	29	179
SS-9	0 to 8	8.1	0.84	1.7	37	3.0	1.9	65	12	23	Sandy Clay Loam	10	27	177
SS-10	0 to 8	7.9	0.96	1.7	39	3.5	2.9	66	17	17	Sandy Loam	16	92	247
SS-11	0 to 8	7.9	1.4	2.3	37	3.3	2.0	65	10	25	Sandy Clay Loam	8.0	43	142
SS-12	0 to 8	8.0	1.6	2.6	45	3.3	1.9	62	15	23	Sandy Clay Loam	6.0	33	107
SS-13	0 to 8	7.8	2.2	1.6	38	2.8	4.6	64	13	23	Sandy Clay Loam	71	14	118
SS-14	0 to 8	7.9	2.0	2.5	41	1.9	0.90	66	13	21	Sandy Clay Loam	12	33	98
SS-15	0 to 8	8.0	1.1	1.7	30	2.7	5.0	68	13	19	Sandy Loam	32	141	268
SS-16	0 to 8	8.2	1.2	1.7	33	2.1	1.0	64	17	19	Sandy Loam	10	23	143
SS-17	0 to 8	8.1	0.82	0.90	33	1.6	5.5	64	11	25	Sandy Clay Loam	35	39	118
SS-18	0 to 8	8.2	0.71	1.5	32	2.0	6.6	64	15	21	Sandy Clay Loam	7.0	25	102
SS-19	0 to 8	8.4	0.36	1.1	33	3.6	1.0	60	17	23	Sandy Clay Loam	7.0	8.0	72
SS-20	0 to 8	8.3	0.69	2.3	36	3.4	1.9	58	19	23	Sandy Clay Loam	6.0	27	95

CONCLUSION

In conclusion, based on available soil physicochemical analytical results, Duraroot has developed the following reclamation plan for the former Myers 14-21 well pad and production facility for alfalfa hay establishment (Attachment A – Myers 14-21 Reclamation Plan).

It has been Duraroot's pleasure to provide these services to Noble Energy, Inc. If you have any questions or comments regarding this soil resource assessment and reclamation plan, please feel free to contact Kelley House, CPSS (khouse@duraroot.com; 406.580.0373).

REFERENCES

Bohn, H.L., B.L. McNeal, and G.A. O'Connor. 1985. Soil Chemistry. John Wiley and Sons, New York.

Colorado Natural Areas Program (CNAP). 1998. Native Plant Revegetation Guide for Colorado: Caring for the Land Series, Volume III. https://cpw.state.co.us/Documents/CNAP/RevegetationGuide.pdf

Hanson, B., S.R. Grattan, and A. Fulton. 1999. Agricultural Salinity and Drainage. Division of Natural Resources Publication 3375. University of California Irrigation Program. University of California, Davis.

McBride, M.B. 1994. Environmental Chemistry of Soils. Oxford University Press, New York.

Soil Science Society of America. 2010. Glossary of Soil Science Terms. Madison, WI. https://www.soils.org/publications/soils-glossary

Thorup, R.M. 1984. Ortho Agronomy Handbook (a practical guide to soil fertility and fertilizer use). The Fertilizer Division, Chevron Chemical Company, San Francisco, California.

United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS). Glossary of Soil Survey Terms. 2015. https://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=nrcseprd407891&ext=pdf

USDA, NRCS. 2019. The PLANTS Database (http://plants.usda.gov, 18 April 2019). National Plant Data Team, Greensboro, NC 27401-4901 USA.

Attachment A:

Myers 14-21 Reclamation Plan

Weld County, Colorado

Prepared for:
Noble Energy Inc.

Prepared by:
Duraroot, LLC

Date:
April 25, 2019

RECLAMATION PLAN
MYERS 14-21 WELL PAD

(1) Seedbed Preparation

These recommended site preparation steps will aid in successful reclamation. Steps may be omitted, conducted in different order, or changed to optimize success and efficiency depending on field conditions, sub-soil properties, and local terrain.

- Deep-rip soil resources to a minimum depth of 18-inches using a parabolic ripper or equivalent equipment to reduce post-construction soil compaction and improve drainage. The shanks on the back of a grader or dozer should NOT be used to reduce soil compaction.
- Apply recommended soil amendments, discussed below, to offset soil nitrogen immobilization and phosphorus deficiencies.
- Finally, disc the site to a depth of 4.0 to 6.0-inches to incorporate fertilizer and to create a seedbed conducive to seedling establishment (disk and harrow, field cultivator, vibra-shank, or other alternative suitable to site conditions). The seedbed should be smooth and firm prior to seeding.

(2) Fertilizer

Soil fertilizer application is recommended at the former Myers 14-21 location to offset nitrogen immobilization due to carbon-rich organic matter additions through straw mulch application, see below. It is recommended to apply soil nitrogen (N) at a rate of 40-pounds per acre. It is further recommended to apply phosphorus (P) at a rate of 30-pounds per acre P_2O_5. Fertilizer should be applied and incorporated into topsoil resources to a depth of 4.0 to 6.0-inches during seedbed preparation activities.

(3) Seeding

Seeding should be conducted using a drill seeder capable of direct seed placement into medium textured soils. A combination drill and packer is desirable. Seed depth is critical for alfalfa. It is recommended that the seed be placed no deeper than ½ -inch below ground surface. The recommended seeding rate of 20-pounds per acre provides approximately 100 PLS per square foot. Alfalfa seed should include a rhizobium bacteria inoculant specific to the alfalfa cultivar selected.

(4) Straw Mulching

Application of straw mulch is recommended to reduce potential water and wind erosion. Recommended straw mulch application rates are between 1.5 to 2.0-tons per acre. This will provide ground coverage of approximately 80 to 90-percent of the ground surface prior to crimping. Once applied the straw mulch should be crimped into the soil. Upon successful crimping the straw mulch should be standing vertically with approximately 40 to 60-percent of the ground surface covered. Straw mulch should be at least 6.0-inches in length. Straw mulch should be crimped sufficiently to cause vertical cover that will not be dislodged by light breezes. Install perimeter fencing to prohibit grazing for the first two growing seasons.

(5) Weed Management

A site-specific IWMP should be implemented once weedy species can be identified. The site could be mowed prior to flowering and seed head production of weedy species. Mowing will reduce competition with desirable species and allow greater opportunity for reclamation success. In addition to mowing, herbicides appropriate for the identified weedy species could be spot applied to eradicate any problematic species. Broadleaf herbicide application should be carefully spot applied to avoid the alfalfa crop. Application timing and rates for herbicides should follow the manufacturer's recommendations. At a minimum, weed management during the first two (2) seasons following reclamation should be diligent to improve establishment of seeded grasses and to prevent weedy species infestation.

Table 1. Reclamation prescription for the former Myers 14-21 well pad and production facility.

	ACTION	SPECIFICATION	PURPOSE
RECLAMATION	Compaction Relief	Deep-rip soil surface to a minimum depth of 18-inches using a parabolic ripper or equivalent equipment.	Ripping will reduce soil compaction and improve drainage and root development.
	Soil Amendments	NA	NA
	Fertilizer	Apply 40-pounds per acre N (with straw mulch application) Apply 30-pounds per acre P_2O_5	Fertilizer application will offset soil nitrogen immobilization and phosphorus deficiencies.
	Seedbed Preparation	Disc the site to a depth of 4.0 to 6.0-inches to incorporate fertilizer. Cultipacking the soil before and after seeding will help stand establishment.	Discing will break up soil clods, incorporate soil amendments, and enhance seed to soil contact.
	Seeding	Drill seed into the soil surface no deeper than ½-inch. Seed mix should include a cultivar-specific rhizobium bacteria (*Rhizobium meliloti*) inoculant.	Drill seeding enhances seed to soil contact.
	Stormwater BMPs and Erosion Control	Crimp straw mulch at a rate of 1.5 to 2.0-tons per acre.	Crimped straw mulch will stabilize and protect soil resources until seed germination and crop establishment occurs. Straw mulch will also protect seeds from desiccation until germination occurs.
	Weed Management	Establish and maintain a site-specific IWMP.	Weedy species will compete with seeded crop for important resources required for germination and seedling establishment.