Soil Salvage Plan

Horseshoe Production Facility

Washington County, Colorado

Prepared for:
St. Croix Exploration Company

Prepared by:
Duraroot, LLC

Date:
August 2021

TOPSOIL SALVAGE PLAN
HORSESHOE – PRODUCTION FACILITY

Site Description

Topsoil depths across the proposed St. Croix Exploration Company (St. Croix) Horseshoe production facility location were evaluated and determined by a Duraroot Certified Professional Soil Scientist (CPSS) on July 16, 2021. The proposed Horseshoe production facility is located in the SE ¼ of the SE ¼ of Section 22, Township 3S, Range 49W in Washington County, Colorado (Figure 1).

Soils within the facility location are mapped primarily as the Valent sand (*Mixed, mesic Ustic Torripsamments*) soil series. The approximate disturbance area of the facility is 7.0 acres. The pre-disturbance land use is native grass adjacent to irrigated crop.

Site Soils

The location's soils were evaluated to establish topsoil depths across the location that are suitable for salvage and reclamation. Topsoil salvage practices should avoid mixing topsoil with subsoil and should avoid soil resources with properties that may limit crop productivity and/or reclamation success. Soil cores were collected using a Giddings hydraulic probe and evaluated using the following physical properties:

- Horizon depths,
- Soil color,
- Soil texture and structure,
- Soil effervescence,
- Plow depth layer, and
- Depth to restrictive layer.

A summary of the observed physical soil properties is as follows:

- **Horizon depths:** The topsoil (A) horizon was observed from 7.0 to 9.0 inches deep across the location. The topsoil (A) horizon was typically delineated by changes in soil texture and structure accompanied by a decrease in root content.
- **Soil color:** Soil color was recorded for each soil horizon and ranged from 10YR 4/3 to 10YR 5/3 in the topsoil (A) horizon and from 10YR 4/4 to 10YR 6/3 in the subsoil.
- **Soil texture and structure:** Soil texture was recorded as sandy loam (SL) and loamy sand (LS) throughout. Soil structure was recorded as granular (gr)/ subangular blocky (sbk) throughout the topsoil (A) horizon. Subsoil structures were recorded as subangular blocky (sbk) to massive (m).
- **Depth to restrictive layer:** Restrictive layers were not observed in any of the samples.
- **Plow depth layer:** A distinct plow depth layer was not observed.
- **Soil effervescence:** Effervescence is used to estimate soil lime ($CaCO_3$) content, as HCl reacts with $CaCO_3$ to produce CO_2. Effervescence with 10-percent HCl solution was not observed indicating low lime ($CaCO_3$) content.

Table 1. Approximate location coordinates and topsoil depths for the individual Horseshoe production facility soil samples.

Sample ID	Latitude	Longitude	Topsoil Depth (inches)
SS1	39.77225	-102.84103	9.0
SS2	39.77174	-102.84102	7.0
SS3	39.77148	-102.84120	8.0

Figure 1. Aerial image of the proposed Horseshoe production facility with soil sample locations and soil salvage zone.

During the field investigation, Duraroot collected three (3) soil cores from the proposed location to establish current soil physicochemical properties (Table 3). Soil cores were collected from within the Valent sand soil series. Soil samples for each delineated horizon were submitted to Ward Laboratories, Inc, (Kearney, NE) for the following agronomic soil properties: saturated paste pH and electrical conductivity (EC), sodium adsorption ratio (SAR), soil organic matter content (SOM), nitrate-nitrogen (NO_3-N), phosphorus (Olsen-P), potassium (K), zinc (Zn), iron (Fe), manganese (Mn), copper (Cu), percent lime ($CaCO_3$), and soil texture. A summary of the soil physicochemical properties is as follows:

- **Soil pH:** Soil pH ranges from 5.4 to 6.3 in the Horseshoe production facility soil samples. Soil pH ranges from strongly acid to slightly acid in the Horseshoe production facility soils. Acidic soil pH may impair crop growth at the Horseshoe production facility.
- **Soil EC:** Soil EC ranges from 0.25 to 2.3 dS/m in the Horseshoe production facility soil samples. Soil EC ranges from non-saline to very slightly saline in the Horseshoe production facility soil samples. Soil EC on the Horseshoe production facility should not a impair crop growth.
- **Soil SAR**: Soil SAR ranges from 0.20 to 2.8 in the Horseshoe production facility soil samples. Soils at the Horseshoe production facility are not sodic. Soil SAR on the Horseshoe production facility should not impair crop growth.
- **Soil Texture**: Soil sample results indicate the location has very coarse soil textures. Soil texture at the Horseshoe production facility was measured as sand with greater than 90 percent sand content. Soil texture is consistent across the location. Coarse soil textures have low water and nutrient retention and may impair crop growth.
- **Soil Organic Matter:** SOM measured in the Horseshoe production facility soils ranges from 0.50 to 1.3 percent. SOM is suitable (> 0.50 percent) for crop production in topsoil (A) horizon soils at the location.
- **Soil Fertility (N-P-K):** Soil nitrogen (NO_3-N) measured in the Horseshoe production facility soils ranges from 2.0 to 185 pounds per acre. Soil phosphorus (Olsen-P) levels in the Horseshoe production facility soils range from 4.6 to 20 ppm. Soil potassium (K) levels in the Horseshoe production facility soils range from 130 to 383 ppm. Soil N and P levels are primarily low in the Horseshoe production facility soils. Soil micro-nutrients (Zn, Fe, Mn, and Cu) measured at the location are suitable for crop growth.

There are no other observed soil properties that may interefere with crop productivity and reclamation success.

Figure 2. Field conditions at the Horseshoe production facility location.

Topsoil Salvage Depth

Topsoil salvage depths were evaluated using soil morphological and physical characteristics of three (3) soil cores collected from the proposed location. Evaluation of soil cores resulted in one (1) topsoil salvage zone, Zone A (Table 2; Figure 1). Approximate location coordinates and topsoil depths for the individual Horseshoe production facility location soil samples are in Table 1.

Zone A: Salvage 0 to 10 inches. There are no salvage limitations within the top 10 inches of soil in Zone A; therefore, it is recommended that the top 10 inches (+/- 15%) of soil be salvaged for reclamation. Due to a decrease in SOM, root content, and firmer soil structure with depth, it is only recommended that the top 10 inches of soil be salvaged on the Horseshoe production facility location in Zone A.

Given that the underlying subsoil had reduced organic matter content and more massive (structureless) soil structure, salvaging 10 inches would greatly reduce the chances of mixing valuable topsoil resources with less desirable subsoil which could reduce soil productivity and impair reclamation efforts.

Table 2. Topsoil balance and salvage depth for the Horseshoe production facility location.

Zone [1]	Area (acres)	Soil Salvage Depth (inches) [2,3]	Estimated Topsoil Volume		Salvage Limitations [4]
			ft^3	yds^3	
Zone A	7.0	10	254,100	9,411	Reduced organic matter content
Total	**7.0**	**10**	254,100	9,411	--

Notes:
1. The soil stripping zones are shown in Figure 1.
2. Soil salvage depths are estimated based on observed soil parameters. Field conditions will dictate actual soil salvage depths.
3. Soil Salvage Depth Total equals the total depth of salvaged soil post re-application.
4. Salvage Limitations indicate soil quality parameters that limit salvage depths.

Table 3. Soil physicochemical data for the Horseshoe production facility location. Parameters in red may impair reclamation success.

Depth (inches)	pH (s.u.)	EC (dS/m)	SAR	$N\text{-}NO_3$	N	P	K	Zn	Fe	Mn	Cu	SOM	Lime	Saturation	Sand	Silt	Clay	Texture
				lb/acre	(ppm)							%						
SS1																		
0 to 9	6.0	0.38	0.40	**12**	4.4	**11**	149	2.2	20	4.5	0.84	1.0	0.10	33	**92**	4.0	4.0	**Sand**
9 to 20	6.1	0.31	0.40	**4.0**	1.3	**8.9**	150	1.1	26	2.4	0.22	**0.50**	0.10	27	**94**	3.0	3.0	**Sand**
SS2																		
0 to 7	6.3	0.30	0.20	**5.0**	2.5	**9.8**	134	3.4	52	4.9	0.62	1.2	0.10	35	**91**	4.0	5.0	**Sand**
7 to 15	6.2	0.25	0.20	**2.0**	1.0	**8.0**	130	1.3	26	2.8	0.26	**0.60**	0.10	29	**93**	3.0	4.0	**Sand**
SS3																		
0 to 8	**5.4**	2.3	2.8	185	77	20	383	1.9	36	16	0.39	1.3	0.10	32	**90**	5.0	5.0	**Sand**
8 to 14	5.8	1.9	0.20	100	56	**4.6**	217	0.86	24	10	0.26	**0.60**	0.10	27	**92**	5.0	3.0	**Sand**

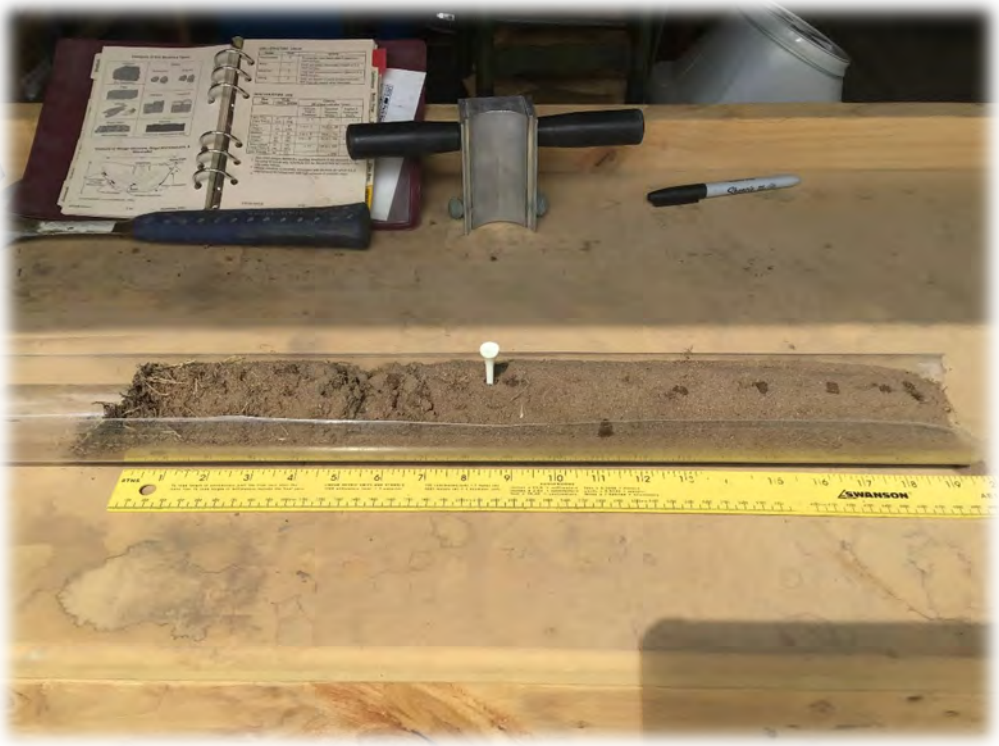

Figure 3. Soil core collected at the Horseshoe production facility location (Soil Sample 1).

Figure 4. Soil core collected at the Horseshoe production facility location (Soil Sample 1).

Figure 5. Soil core collected at the Horseshoe production facility location (Soil Sample 2).

Figure 6. Soil core collected at the Horseshoe production facility location (Soil Sample 2).