SECTION 20 TIER 2 SOIL ANALYSIS FOR PROPOSED CBNG PRODUCED WATER DISCHARGES TO BEAVER CREEK, CAMPBELL COUNTY, WYOMING

KC HARVEY

Soil & Water Resource Consulting

AN ENERCREST COMPANY

SECTION 20 TIER 2 SOIL ANALYSIS FOR PROPSED CBNG PRODUCED WATER DISCHARGES TO BEAVER CREEK, CAMPBELL COUNTY, WYOMING

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1.0 INTRODUCTION

This report presents a Section 20 "Tier 2" assessment of soils and irrigated fields in Beaver Creek downstream from the proposed discharge of coalbed natural gas (CBNG) produced water in Campbell County, Wyoming. The proposed discharge of produced water will be from Bill Barrett Corporation (BBC) in accordance with WYPDES Permit Application No. WY0055638. Marathon Oil Company (Marathon), Williams Production RMT Company (Williams), and Yates Petroleum Corporation (Yates) also plan to apply for new and/or renewal WYPDES permits in the Beaver Creek watershed and participated in funding this Section 20 field study. Marathon, Williams, and Yates will address their permitting plans with the DEQ collectively and individually in the future.

The purpose of this report is to supply the Wyoming Department of Environmental Quality (WDEQ) with the baseline soil data necessary to derive effluent limits and IMP standards for electrical conductivity (EC) and sodium adsorption ratio (SAR) in accordance with the Tier 2 approach described in the current version of the Agricultural Use Protection Policy.

This report includes an evaluation of land owned by the Little Buffalo Ranch LLC., Trigg Marquiss, The Flying T Land Company LP, and Iberlin Ranch LP, in Campbell and Johnson Counties, Wyoming. Two naturally irrigated fields, one on the Little Buffalo Ranch and the other on the Flying T Ranch were sampled, as well as a field passively irrigated with a spreader dike system found on the Iberlin Ranch (Figure 1). The sampled fields were identified as possible irrigated fields by the WDEQ based on their review of color infrared photography. The WDEQ identified an additional field downstream of the Iberlin field; however, the soil chemistry of this field has potentially been influenced by on-going upstream discharge of CBNG produced water. The fields investigated, as part of this analysis, have reportedly not been influenced by CBNG produced water. The fields were investigated and sampled by a certified professional soil scientist from KC Harvey, Inc. Energy Laboratories, Inc. of Helena, Montana, performed the sample analyses.

Section 2 below describes the baseline hydrologic, soil, and vegetation conditions that are representative of the naturally and passively irrigated soils in the Beaver Creek watershed. References cited throughout the report are provided in Section 3. Tables, figures, and appendices are located at the end of this report.

2.0 BASELINE CONDITIONS

2.1 HYDROLOGIC CONDITIONS

BBC's proposed CBNG produced water discharges will occur to a tributary to Beaver Creek located upstream of the Iberlin field sampled for this Tier 2 report. Beaver Creek drains an 84 square mile watershed in Campbell County, Wyoming (Figure 1). Beaver Creek flows northwest, into Johnson County where it converges with the Powder River. Beaver Creek and its tributaries are considered ephemeral; natural flow occurs periodically in response to rainfall and snowmelt events.

In the areas evaluated, the Beaver Creek channel is generally well defined and incised. In the upper portion (LB01-LB03, Figure 2) of the Little Buffalo field, the Beaver Creek channel appears poorly defined (Photos 1 through 3). Based on field observations, Beaver Creek exhibits its minimum channel capacity in the upper portion of the Little Buffalo field; which suggests the Little Buffalo field may be flooded more frequently than the Flying T field and potentially the Iberlin field. The Beaver Creek channel appears well defined in the lower portion of the Little Buffalo field (LB04-LB08) and throughout the Flying T and Iberlin fields (Figures 2, 3, and 4; Photos 4 through 6). Silt deposition is evident near some of the Iberlin spreader dikes and surrounding areas; however the Beaver Creek channel remains well defined in most areas.

According to a search of the Wyoming State Engineer's Office water rights database, there are no permitted irrigation diversions on Beaver Creek. A spreader dike system is used to passively irrigate the Iberlin field. The Iberlin spreader dike system is in reasonably good condition and effectively spreads water to adjacent areas during run off events. The fields on the Little Buffalo and Flying T Ranches may be naturally irrigated. Actual natural irrigation could not be confirmed at the sites due to the time sampling occurred. However, based on aerial photography and the site visit, natural irrigation is highly probable in the areas sampled. For the purposes of this report, downstream agricultural use consists of natural irrigation, passive irrigation through periodic flooding of the spreader dike system during run off events, and livestock water use.

Historic water quality data are not available in the Beaver Creek drainage or other analog drainages. Although the United States Geological Survey and the Wyoming Department of Environmental Quality cooperatively operate a gage station at the confluence of Beaver Creek and the Powder River, water quality data was not recorded prior to CBNG discharges and thus the available data is not helpful for the purposes of this report.

2.2 SOIL CONDITIONS

Three fields along Beaver Creek were investigated to document current soil conditions (Figures 2, 3, and 4). In the Little Buffalo and Flying T fields sample collection occurred in portions of the field nearest the Beaver Creek channel (Figures 2 and 3). In the Iberlin field, sample collection occurred adjacent to and in between the spreader dikes (Figure 4). The Little Buffalo field is located in Section 26 of Township 47 North, Range 75 West. The Flying T field is located in Sections 8 and 17 of Township 47 North, Range 75 West. The Iberlin field is located in Sections 2 and 3 of Township 47 North, Range 76 West and Section 34 of Township 48 North, Range 76 West (Figure 1).

2.2.1 NRCS SOIL MAPPING UNITS

Soils bordering Beaver Creek have been mapped in the Campbell County soil survey (Figure 5). The fields adjacent to Beaver Creek have been mapped as an Emigha loam, 0 to 3 percent slopes, an Emigha, sodic, Arvada, thick surface complex, 0 to 4 percent slopes, and a Haverdad-Kishona complex, 0 to 6 percent slopes (Campbell County Soil Survey, Southern Part, 2005; Figure 5). The official NRCS descriptions for the Emigha, Arvada, Haverdad and Kishona soil series are included in Appendix A along with reported soil chemical data (National Cooperative Soil Survey, 2002, 2003, and 2005; Campbell County, Wyoming, Southern Part, Soil Survey, 2005).

Emigha soils are very deep, well-drained soils that formed in alluvium derived from shale on low terraces and upland toeslopes. Soil textures include loam, clay loam, and silty clay loam; clay content ranges from 15 to 35 percent. Emigha soils receive between 10 and 14 inches of precipitation annually; over half of which falls as rain or snow in late spring and early summer. Soil permeability is slow to moderate. Emigha soils are used for rangeland, wildlife habitat, and infrequently as hayland and pasture. Native vegetation includes western wheatgrass, needleandthread, blue gamma, and green needlegrass.

In the Beaver Creek fields two variations of the Emigha series are reportedly present. In areas mapped as the Emigha loam, reported soil EC ranges from 0 to 8 dS/m and SAR varies between 0 and 13. In areas mapped as the Emigha, sodic, Arvada, thick surface complex soil EC ranges from 2 to 16 dS/m and SAR ranges from 2 to 25. This soil chemistry data indicates that saline-sodic conditions exist naturally in these soils (National Cooperative Soil Survey, 2003b; Campbell County, Wyoming, Southern Part, Soil Survey, 2005).

Arvada soils are very deep, well-drained soils that formed in alluvium and colluvium derived from sodic shales on alluvial fans, fan remnants, fan terraces, and hillslopes. Soil texture ranges from sandy loam to clay. Clay content may be as high as 60 percent in some soil horizons, but generally ranges from 18 to 50 %. Soil EC ranges from 0 to

16 dS/m; and SAR ranges from 0 to 25. Arvada soils typically include a natric soil horizon with a soil pH between 8.8 and 10; a soil EC of 4 to 16 dS/m; and an exchangeable sodium percentage (ESP) range of 15 to 34 %. Arvada soils receive approximately 12 inches of precipitation per year; most of which occurs in April, May, and June. Permeability is very slow, which tends to create high or very high runoff. Arvada soils are used as rangeland and wildlife habitat. Native vegetation includes alkali sacaton, Gardner saltbrush, western wheatgrass, and scattered greasewood (National Cooperative Soil Survey, 2003a; Campbell County, Wyoming, Southern Part, Soil Survey, 2005).

Haverdad soils are very deep, well-drained soils that formed in stratified alluvium on flood plains and low terraces. Textures range from sandy loam to clay loam, clay content ranges from 18 to 35 percent. Haverdad soils generally have mixed clay mineralogy. Soil EC ranges from 0 to 4 dS/m throughout the profile; SAR varies between 0 and 5. Haverdad soils receive an average of 11 inches of precipitation per year, with over half the precipitation occurs in late spring and early summer. Permeability is moderate. Flooding on Haverdad soils occurs for brief periods during spring runoff and after thunderstorms. These soils are typically used for grazing with principal native vegetation being big sagebrush, western wheatgrass, greasewood, and annual grasses and forbs (National Cooperative Soil Survey, 2002; Campbell County, Wyoming, Southern Part, Soil Survey, 2005).

Kishona soils are very deep, well-drained soils that formed in sandstone and shale alluvium on fan aprons, fan remnants, hills, ridges, and terraces. Clay content ranges from 20 to 35 percent and soil textures are generally loam, clay loam, and silty clay loam. The clay mineralogy of Kishona soils is mixed. Soil EC in the Bk horizon ranges from 0 to 8 dS/m. The SAR of Kishona soils ranges from 0 to 5. Kishona soils receive approximately 12 inches of precipitation each year; the bulk of the precipitation falls during April, May, and June. Permeability is moderate and runoff tends to be slow to medium. Kishona soils are sometimes irrigated where water is available; small grains and hay are usually produced for harvest or livestock grazing. Native vegetation includes: Gardner Saltbrush, western wheatgrass, bottlebrush squirreltail, and bud sagebrush (National Cooperative Soil Survey, 2005; Campbell County, Wyoming Southern Part, Soil Survey, 2005).

2.2.2 SOIL SAMPLING AND ANALYSIS METHODS

A certified professional soil scientist from KC Harvey, Inc. conducted a soil investigation of the three Beaver Creek fields. The Iberlin field soil investigation occurred on April 18, 2007; the soil investigation of the Little Buffalo and Flying T fields occurred on May 17, 2007. Soil samples were collected from eight locations in the Little Buffalo field; seven locations in the Flying T field; and from ten locations in the Iberlin field. Each sample location was marked using a handheld global positioning system (GPS) unit (Figures 2,

3, and 4). Soil samples were collected using a truck-mounted Giddings Probe (Giddings Machine Company, Windsor, Colorado). At each sample location, soil samples were collected from six depth increments: 0 to 6, 6 to 12, 12 to 24, 24 to 36, 36 to 48, and 48 to 72 inches. Samples were composited by depth for a total of six samples per field. Samples were delivered to Energy Laboratories, Inc., Helena, Montana for analysis of pH, electrical conductivity (ECe), dissolved calcium, dissolved magnesium, dissolved sodium, sodium adsorption ratio (SAR), saturation percentage, exchangeable sodium, cation exchange capacity (CEC), exchangeable sodium percentage (ESP), texture (percent sand, silt, and clay), percent lime, percent organic matter (0-6 inch samples only) and clay mineralogy (0-6 inch samples only). Results of the physical and chemical soil analyses from the Beaver Creek fields are summarized in Table 1 and 2. The original laboratory reports are provided in Appendix B.

2.2.3 SOIL PHYSICAL CONDITIONS

Soil physical properties affect aeration rates, water infiltration, water storage, and movement of water through the soil profile. The soil texture of the Little Buffalo field is loam (Table 1). Soil textures in Flying T field are loam and clay (Table 1). In the Iberlin field soil textures include clay loam and silty clay loam (Table 1). Clay content, in the three Beaver Creek fields, ranges from 19 to 41 % in all depths sampled (Table 1). Compared to other soils in the Powder River Basin, the clay contents found in the soils at the Beaver Creek site are considered typical.

The effects associated with sodic irrigation water may depend upon the clay mineralogy of the soil. The clay mineralogy of the Beaver Creek surface soil samples (0 to 6 inches) was analyzed using X-ray diffraction (XRD). Smectite composes 40 to 46 % of the clay fraction; followed closely by illite and kaolinite, which range from 34 to 40 and 20 to 21 %, respectively (Table 1). Smectitic clays are 2:1 clays that expand upon wetting and shrink after drying. The degree of swelling may increase when sodic waters are applied to such clays. Non-expanding clays, such as illite and kaolinite, are less likely to be affected by sodic waters.

Percent organic matter in the soil samples ranges from 0.64 to 4.6 % (Table 1), which is considered typical for the region.

2.2.4 SOIL CHEMICAL PROPERTIES

SOIL PH

Soil pH is perhaps the most important chemical characteristic of the soil and indicates the intensity of the acidic or basic condition of the soil. Soil pH serves as a general index to the availability of plant nutrients, potential toxicity problems, and sodic soil conditions. A soil pH of 6.5 to 8.4 is ideal for most range plants. As the soil pH

increases above or decreases below this range, the availability of phosphorus, calcium, magnesium, iron, manganese, zinc, copper, cobalt, and boron may become limiting to plants. In the Beaver Creek soil samples, soil pH ranges from 7.2 to 8.2 (Table 2).

SOIL SALINITY

Soil salinity is simply the amount of soluble salts in a soil, and is measured by the electrical conductivity (ECe) of the saturated paste extract. The salinity of a soil is important because high salt levels make it difficult for plants to obtain water (Bohn, et al., 1985). Saline soils are conventionally defined as having ECe values of greater than 4 dS/m, however sensitive plants can be affected at 2 dS/m and more tolerant plants (e.g., many of the native species of the Powder River Basin) are productive at ECe levels greater than 8 dS/m. In the arid western United States, naturally occurring saline soils are more common because arid regions are subject to high evaporation rates, thus allowing salt concentration to occur (Soil Improvement Committee, California Plant Health Association, 2002).

Soil sample ECe ranges from 2.0 to 13.2 dS/m in all depth increments (0 to 72 inches) of the Beaver Creek fields (Table 2). These values are comparable to the values reported by the NRCS for the Emigha, Arvada, Haverdad, and Kishona soil series (National Cooperative Soil Survey, 2002, 2003, and 2005; Campbell County, Wyoming, Southern Part, Soil Survey, 2005).

An average soil ECe was calculated to a depth of 48 inches. As specified in the Agricultural Use Protection Policy, the 48-inch depth is representative of the average root zone depth of the grass species present in the Beaver Creek fields. The average soil ECe is reflective of the long-term application of Beaver Creek water and will be used to estimate the background water EC. The average soil EC was calculated using the following formula:

$$\text{Average Soil ECe} = (((ECe_{0\text{-}6} + ECe_{6\text{-}12}) \div 2) + ECe_{12\text{-}24} + ECe_{24\text{-}36} + ECe_{36\text{-}48}) \div 4$$

Where, $ECe_{0\text{-}6}$ is the ECe measured in the first six inches of the root zone (0 to 6 inches). Because soil samples were collected from the 0 to 6, and 6 to 12 inch increments, the ECe results for these two depths were averaged together to derive a 0 to 12 inch ECe value for the average soil ECe calculation. The average soil ECe for the 0 to 48 inch root zone ranged from 7.2 to 10.8 dS/m in the Beaver Creek fields with an overall average of 9.1 dS/m (Table 2). Therefore, all fields sampled exhibit average soil ECe values of greater than 4.0 dS/m, which classifies these soils as saline (Table 2). Only plants moderately to highly salt tolerant, have the ability to reach maximum yields in these soils.

SOIL SODICITY

Sodic soils are "nonsaline soils containing sufficient exchangeable sodium to adversely affect crop production and soil structure" (Soil Science Society of America, 2001). High levels of adsorbed sodium tend to disperse clay particles thereby sealing the soil. The result can produce clogged soil pores, hard surface crusts, and reduced infiltration, permeability, and oxygen diffusion rates; all of which can interfere with or prevent plant growth. By definition, sodic soils are those that have an exchangeable sodium percentage (ESP) greater than 15 (Levy et al. 1998; Abrol et al., 1988; Evangelou, 1998; McNeal and Coleman, 1966; Sparks, 1995; Sumner et al., 1998; Shainberg et al., 1971; Soil Improvement Committee, California Plant Health Association, 2002).

Clay minerals are the most physically and chemically reactive components of the sand, silt, and clay fractions of the soil. Soil clay minerals are negatively charged and consequently attract ions with a positive charge such as calcium, magnesium, potassium, and sodium. Positively charged ions, called cations, compete with each other in the soil solution for access to bonding sites based on its valence and hydrated size. Every soil has a definite capacity to adsorb positively charged cations. This is termed the cation exchange capacity (CEC). The various adsorbed cations (such as calcium and sodium) can be exchanged one for another and the extent of exchange depends upon their relative concentrations in the soil solution (dissolved), the ionic charge (valence), the nature and amount of other cations, etc. ESP is, accordingly, the amount of adsorbed sodium on the soil exchange site expressed as a percent of the cation exchange capacity in milliequivalents per 100 grams of soil (meq/100 g). Thus,

ESP = (exchangeable sodium / cation exchange capacity) x 100.

By definition, sodic soils occur when greater than 15% of the ions bonded to the clay minerals are sodium; which has a +1 valence and a large hydrated radius. When the ESP exceeds 15%, the large hydrated sodium ions can wedge in-between the clay minerals, resulting in soil swelling (Levy et al., 1998). This causes negative effects on the physical structure of the soil. Upon re-wetting, the clay minerals may disperse and settle into soil pores, effectively clogging the pores and reducing the efficiency of air exchange, water infiltration, and permeability (i.e., hydraulic conductivity). In general, soils with moderately high to high clay contents are at greater risk. The type of clay mineral is also important, with the expanding smectitic clays being the most problematic.

Soil ESP values range from 2.7 to 29 percent in the Beaver Creek soil samples (Table 2). The average soil ESP, to a depth of 48 inches, was calculated using the same approach as was used to calculate the average soil ECe. The average soil ESP, to a depth of 48 inches, ranges from 16 to 18.8 percent. Sodic soil conditions exist naturally in the Little Buffalo, Flying T and Iberlin fields; and, when combined with the measured salinity, the Little Buffalo, Flying T, and Iberlin fields are considered saline-sodic (Table

2). Saline-sodic soils are soils with ESP values greater than 15 percent, EC above 4 dS/m, and a pH of 8.5 or less (Brady, 1990; Soil Science Society of America, 2001). Saline-sodic soils are especially challenging to manage because the high salt content and the excess sodium ions can affect plant growth. The soil chemistry of the fields sampled along Beaver Creek indicates that these soils are naturally enriched with salinity and sodicity and that crop yield potential is likely limited.

Saturation percentage is an index of the swelling capacity and the tendency to form dispersive conditions in a soil (Merrill et al., 1987). Saturation percentage is the amount of water, by weight, necessary to form a minimally flowable paste from dry soil materials (Merrill et al., 1987). In general, a saturation percentage of less than 80% indicates the soil does not have a tendency to swell, which also reduces the tendency for dispersion. The saturation percentages measured in the Beaver Creek soils range from 42 to 62 % (Table 1), which indicates non-dispersed, conditions.

2.3 VEGETATION CONDITIONS

Native shrubs, native forbs, and native and non-native forage grasses are present in each of the Beaver Creek fields. Salt cedar, greasewood, and sagebrush are the dominant native shrub species. Cheatgrass was the only grass species identified; however additional grass and forb species were present. In the Iberlin field, cottonwood stands were present near the stream channel. A formal vegetation inventory was not conducted on Beaver Creek because Tier 2 assessments do not require vegetation inventories.

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Table 1. Soil physical analysis results for the Beaver Creek site.[1,2]

Site	Depth	Texture	Sand	Silt	Clay	Surface Clay Mineralogy[3]	Saturation Percentage	Organic Matter
	inches		%					
Little Buffalo	0-6	Loam	42	36	22	Smectite 42 Illite 37 Kaolinite 21	62	4.6
	6-12	Loam	26	49	25		57	2.5
	12-24	Loam	32	45	23		56	1.6
	24-36	Loam	33	42	25		53	1.4
	36-48	Loam	35	40	25		49	1.4
	48-72	Loam	46	35	19		45	1.0
Flying T	0-6	Clay	31	28	41	Smectite 46 Illite 34 Kaolinite 20	56	3.5
	6-12	Loam	31	48	21		54	1.4
	12-24	Loam	33	45	22		59	0.67
	24-36	Loam	29	46	25		60	0.94
	36-48	Loam	35	42	23		52	0.91
	48-72	Loam	45	34	21		49	0.64
Iberlin	0-6	Silty Clay Loam	14	53	33	Smectite 40 Illite 40 Kaolinite 20	53	2.2
	6-12	Clay Loam	26	44	30		48	1.4
	12-24	Clay Loam	23	45	32		50	1.2
	24-36	Clay Loam	32	38	30		46	0.94
	36-48	Clay Loam	31	41	28		45	1.0
	48-72	Clay Loam	33	39	28		42	0.68

Notes:

1. Samples were collected on Apri 18, 2007 at the Iberlin site and on May 17, 2007 at the Flying T and Little Buffalo sites by KC Harvey, Inc. using a Giddings Probe. Samples were analyzed by Energy Laboratories, Inc., Helena, Montana.

2. Abbreviations used are as follow: % = percent.

3. Surface clay mineralogy was determined for the 0 to 6 inch sample only. X-ray diffraction (XRD) analysis was completed by DCM Science Laboratory, Inc., Wheat Ridge, Colorado on April 30, 2007 for the Iberlin site and on May 25, 2007 for the Flying T and Little Buffalo sites.

Table 2. Soil chemical analysis results for the Beaver Creek site.[1,2]

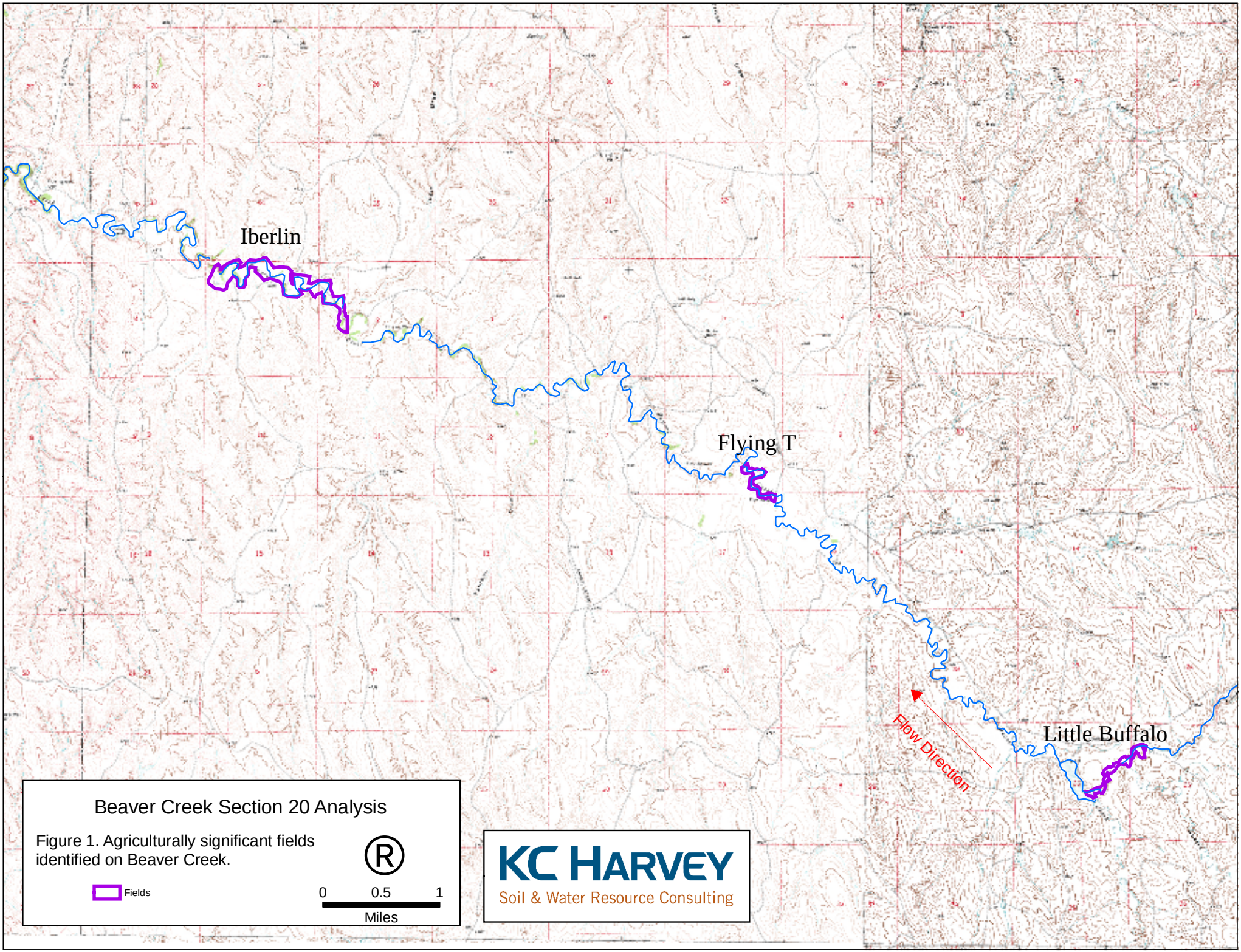
Site	Depth	pH	Electrical Conductivity at 25° C (EC)	Average EC to a Depth of 48 inches[3]	Calcium	Magnesium	Sodium	Sodium Adsorption Ratio (SAR)	Cation Exchange Capacity (CEC)	Exchangeable Sodium	Exchangeable Sodium Percentage (ESP)	Average ESP to a Depth of 48 inches[3]	Lime as $CaCO_3$
	inches	s.u.	dS/m		meq/L				meq/100 g		%		
Little Buffalo	0-6	7.2	3.69	9.4	20.2	6.86	14.4	3.9	30	1.4	4.5	18.8	2.9
	6-12	7.7	5.62		19.7	9.84	40.9	11	25	2.6	10		3.7
	12-24	8.1	12.1		18.8	29.8	109	22	23	6.9	29		3.4
	24-36	8.0	12.5		20.7	36.5	96.4	18	21	4.6	22		3.1
	36-48	7.9	8.41		19.6	31.6	66.1	13	20	3.4	17		3.6
	48-72	7.8	7.69		22.0	24.2	58.9	12	19	2.4	13		3.6
Flying T	0-6	7.3	4.78	10.8	21.7	10.2	26.3	6.6	26	1.4	5.4	16	3.3
	6-12	7.9	9.16		21.1	18.0	72.6	16	22	3.2	15		3.4
	12-24	8.2	13.2		19.9	33.7	126	24	22	4.3	19		4.2
	24-36	8.2	12.3		24.1	32.6	123	23	22	3.7	17		4.7
	36-48	8.0	10.9		22.9	31.6	91.9	18	20	3.6	18		4.6
	48-72	7.9	10.9		23.5	31.2	92.5	18	19	3.1	16		4.0
Iberlin	0-6	7.4	2.01	7.2	14.9	4.87	4.35	1.4	32	0.8	2.7	16	4.9
	6-12	7.7	4.61		21.1	9.76	27.8	7.1	27	2.0	7.4		4.0
	12-24	7.9	7.35		21.0	18.1	77.2	17	27	4.6	17		4.7
	24-36	8.0	10.1		19.3	21.7	95.6	21	23	5.6	24		4.6
	36-48	7.9	7.93		19.4	17.3	67.5	16	22	3.9	18		4.3
	48-72	7.9	7.07		18.2	16.2	54.0	13	21	3.2	15		4.0
			Average EC:	**9.1**							**Average ESP:**	**17.0**	

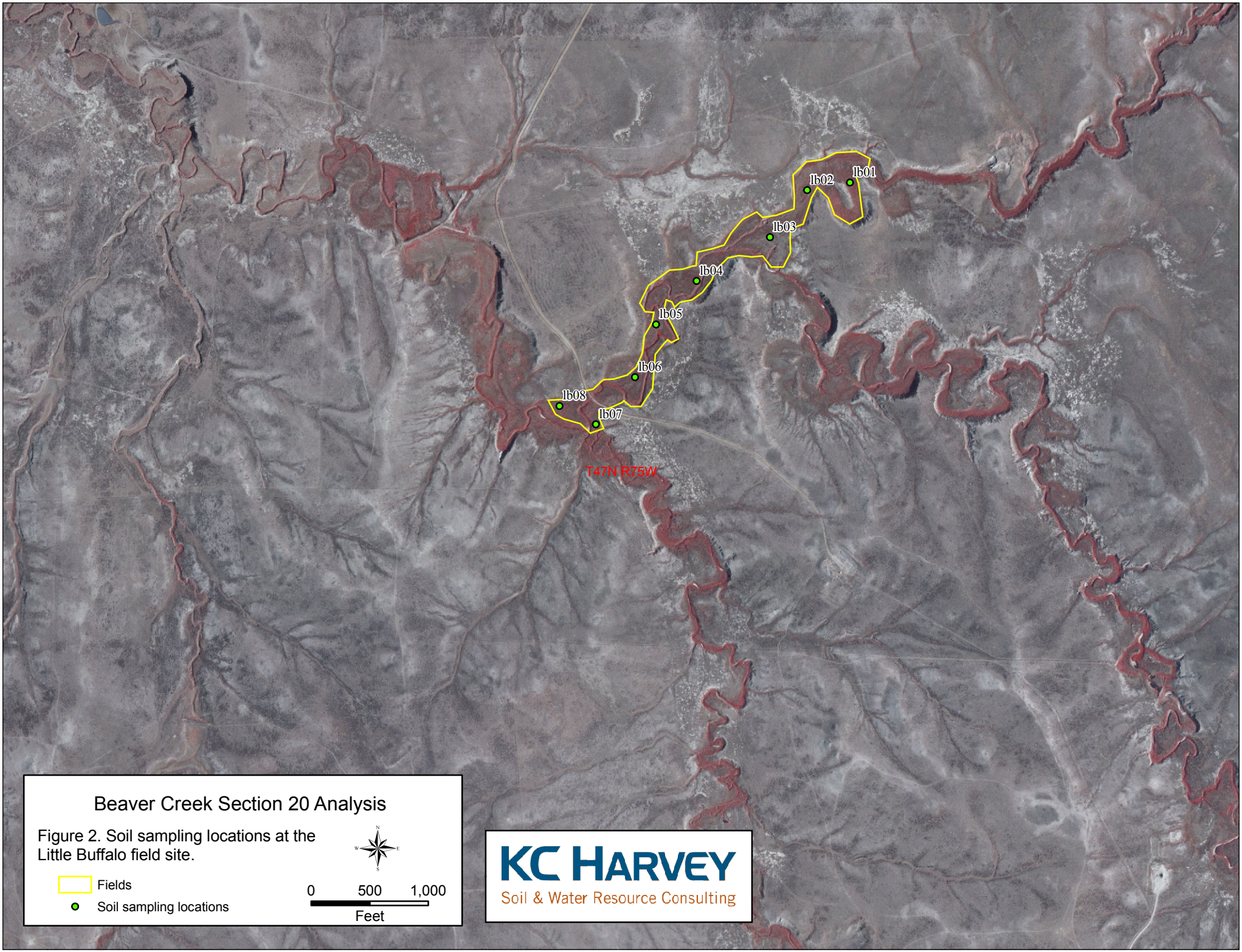
Notes:

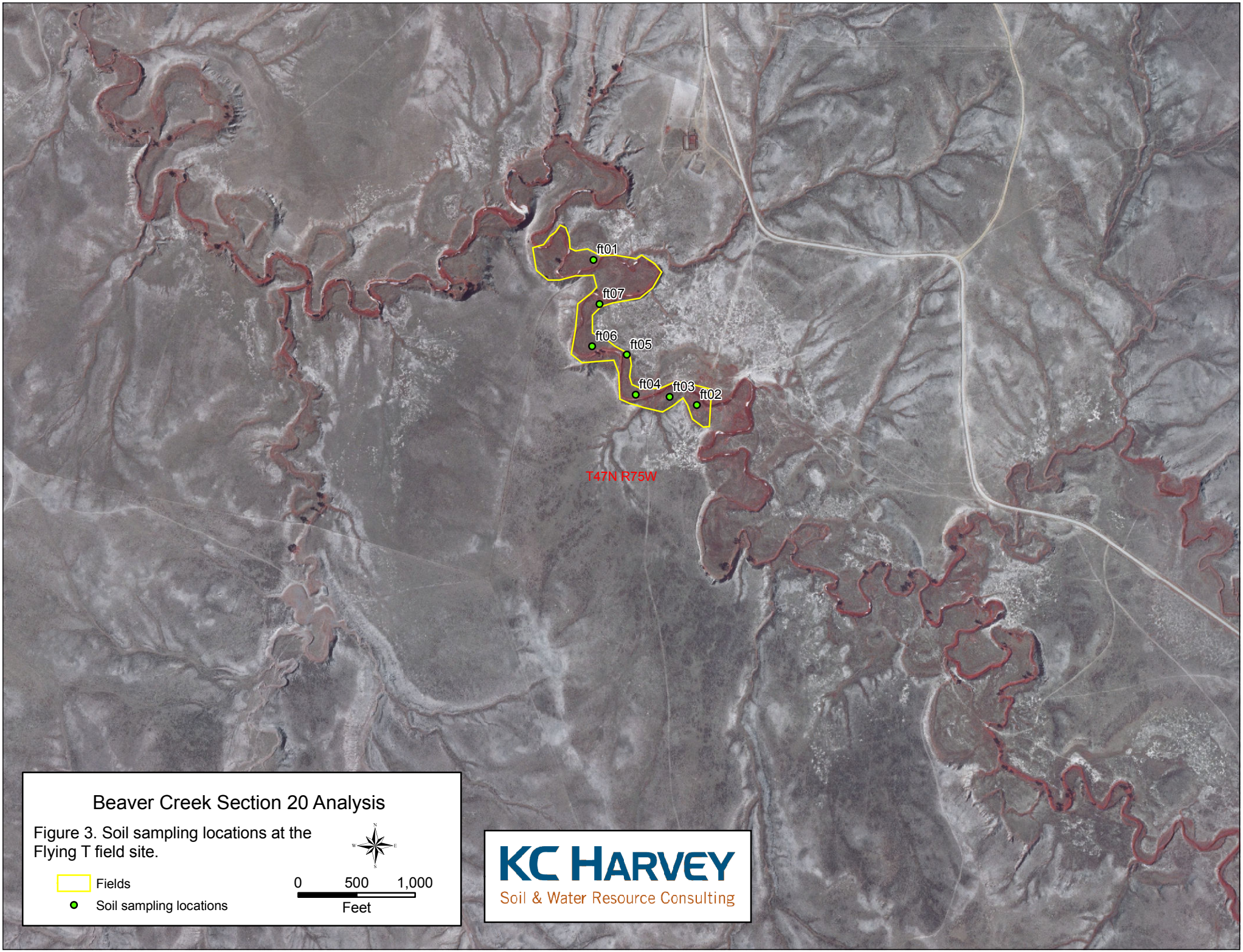
1. Samples were collected on April 18, 2007 at the Iberlin site and on May 17, 2007 at the Flying T and Little Buffalo sites by KC Harvey, Inc. using a Giddings Probe. Samples were analyzed by Energy Laboratories, Inc., Helena, Montana.

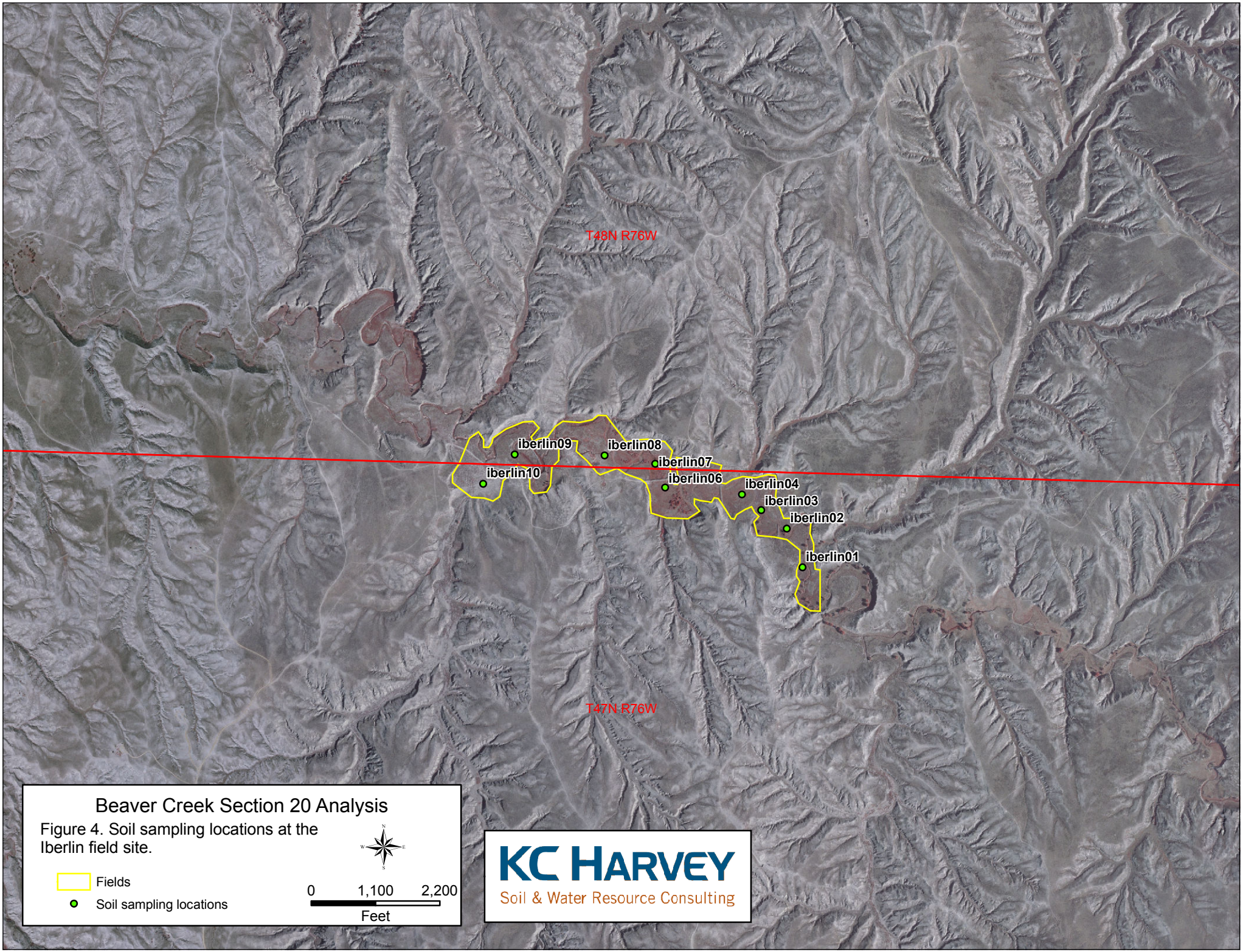
2. pH, EC, calcium, magnesium, and sodium analyses were conducted using a saturated paste extract. Abbreviations used are as follows: s.u. = standard units; dS/m = deciSiemens per meter; meq/L = milliequivalents per liter; meq/100 g = milliequivalents per 100 grams of soil, and % = percent.

3. Average EC and ESP to a depth of 48 inches was calculated by averaging the 0 to 6 and 6 to 12 inch depths to derive a 0 to 12 inch value, then averaging together each 12 inch depth increment to a depth of 48 inches.


Iberlin
Flying T
Little Buffalo
Flow Direction
Beaver Creek Section 20 Analysis
Figure 1. Agriculturally significant fields identified on Beaver Creek.
Fields
0
0.5
1
Miles
KC HARVEY
Soil & Water Resource Consulting


lb01
lb02
lb03
lb04
lb05
lb06
lb07
lb08
T47N R75W
Beaver Creek Section 20 Analysis
Figure 2. Soil sampling locations at the Little Buffalo field site.
Fields
Soil sampling locations
0
500
1,000
Feet
KC HARVEY
Soil & Water Resource Consulting


ft01
ft07
ft06
ft05
ft04
ft03
ft02
T47N R75W
Beaver Creek Section 20 Analysis
Figure 3. Soil sampling locations at the Flying T field site.
Fields
Soil sampling locations
0
500
1,000
Feet
KC HARVEY
Soil & Water Resource Consulting


T48N R76W
T47N R76W
iberlin09
iberlin08
iberlin07
iberlin10
iberlin06
iberlin04
iberlin03
iberlin02
iberlin01
Beaver Creek Section 20 Analysis
Figure 4. Soil sampling locations at the Iberlin field site.
Fields
Soil sampling locations
0
1,100
2,200
Feet
KC HARVEY
Soil & Water Resource Consulting

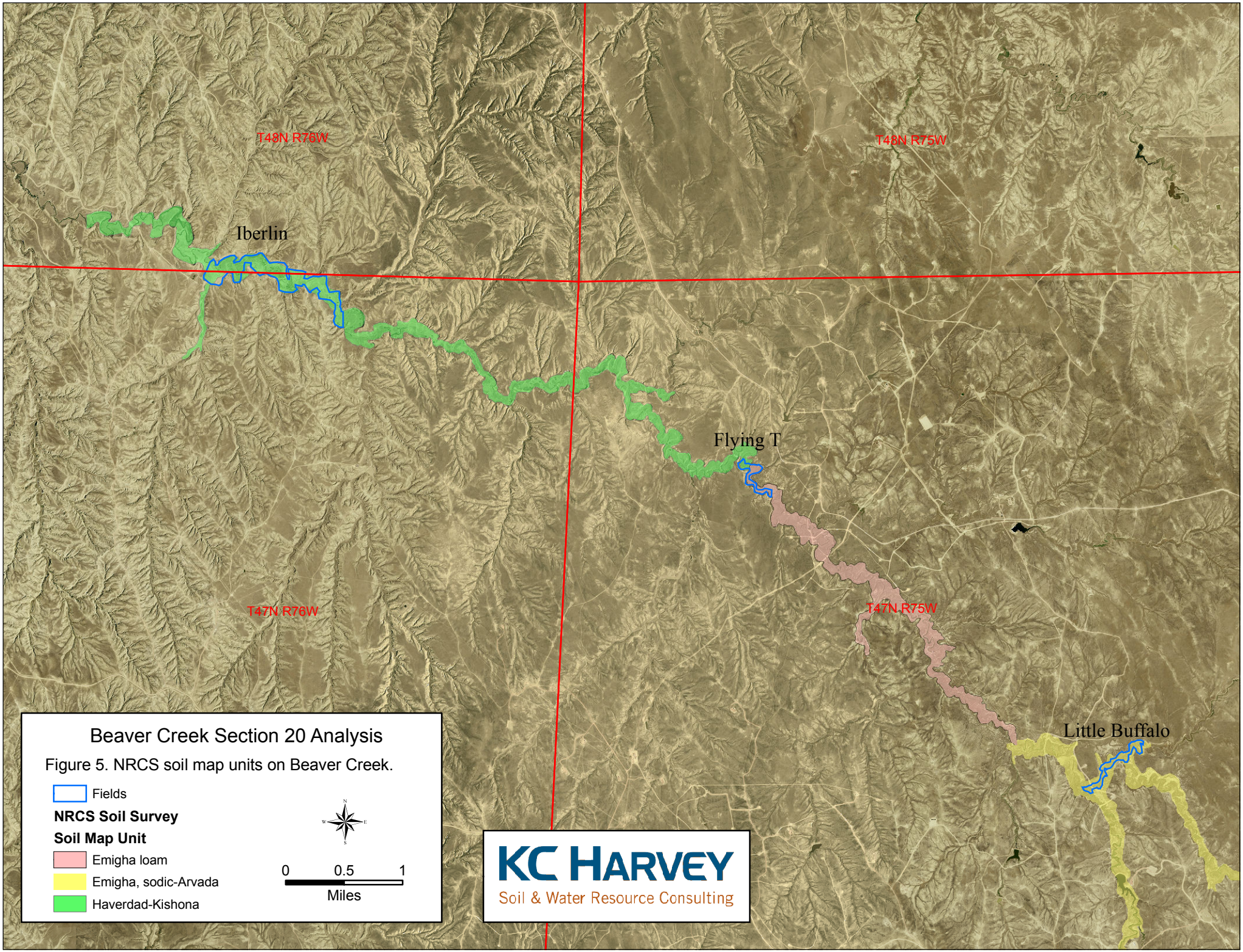

T48N R76W
T48N R75W
Iberlin
Flying T
T47N R76W
T47N R75W
Little Buffalo
Beaver Creek Section 20 Analysis
Figure 5. NRCS soil map units on Beaver Creek.
Fields
NRCS Soil Survey
Soil Map Unit
Emigha loam
Emigha, sodic-Arvada
Haverdad-Kishona
0
0.5
1
Miles
KC HARVEY
Soil & Water Resource Consulting

Photo 1: Little Buffalo Field

Photo 2: Little Buffalo Field

Photo 3: Little Buffalo Field

Photo 4: Flying T Field

Photo 5: Flying T Field

Photo 6: Iberlin Field

Appendix A

LOCATION EMIGHA WY

Established Series
JWW-MCS-CJH
02/2003

EMIGHA SERIES

The Emigha series consists of very deep, well drained soils formed in alluvium derived from shale. Emigha soils are on upland toeslopes and low terraces. Slopes are 0 to 4 percent. The mean annual precipitation is about 13 inches, and the mean annual temperature is about 47 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, mesic Ustifluventic Haplocambids

TYPICAL PEDON: Emigha loam -- on an east facing slope of 1 percent, utilized as rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 1 inch; light brownish gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) moist; weak fine platy structure; soft, very friable, slightly sticky and slightly plastic; many fine and very fine roots; slightly alkaline (pH 7.4); abrupt smooth boundary. (1 to 3 inches thick)

Bw1--1 to 8 inches; brown (10YR 5/3) silty clay loam, brown (10YR 4/3) moist; moderate medium and fine prismatic structure parting to weak fine subangular blocky; hard, friable, sticky and plastic; many fine and very fine roots; slightly effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

Bw2--8 to 19 inches; pale brown (10YR 6/3) silty clay loam, brown (10YR 4/3) moist; moderate medium and fine prismatic structure parting to weak fine subangular blocky; slightly hard, friable, sticky and plastic; common fine and very fine roots; slight effervescence, few faint seams and masses of calcium carbonate; strongly alkaline (pH 8.6); clear smooth boundary. (Combined Bw horizons 9 to 18 inches thick)

Bk1--19 to 30 inches; brown (10YR 5/3) silty clay loam, brown (10YR 4/3) moist; massive; slightly hard, friable, sticky and plastic; few fine and very fine roots; strong effervescence, common seams and masses of calcium carbonate; strongly alkaline (pH 8.6); gradual wavy boundary. (0 to 25 inches thick)

Bk2--30 to 60 inches; pale brown (10YR 6/3) clay loam, stratified with thin layers of silty clay loam, silt loam, and loam, brown (10YR 4/3) moist; massive; slightly hard, friable, sticky and plastic; few very fine roots; strong effervescence, many seams and masses of calcium carbonate; moderately alkaline (pH 8.4).

TYPE LOCATION: Campbell County, Wyoming; about 1,320 feet east and 550 feet north of the southwest corner of section 31, T. 46 N., R. 73 W. 43 degrees 54 minutes 47 seconds north latitude and 105 degrees 41 minutes 4 seconds west longitude.

RANGE IN CHARACTERISTICS: Depth to the base of the cambic horizon ranges from 12 to 20 inches. Depth to stratified material ranges from 14 to 30 inches. Depth to calcium carbonate ranges from 0 to 10 inches. The soil is usually dry. It is moist in April, May, and early June. The mean annual soil temperature is 47 to 51 degrees F.

The A horizon has hue of 10YR or 2.5Y, value of 5 or 6 dry, and chroma of 2 through 4.

The Bw horizon has hue of 10YR or 2.5Y, value of 5 or 6 dry, and chroma of 2 to 4. Texture is silty clay loam or silt loam with 28 to 35 percent clay, and less than 15 percent fine and coarser sand. Exchangeable sodium ranges from 1 to 15 percent. Reaction is moderately alkaline or strongly alkaline.

The Bk horizon has hue of 10YR or 2.5Y, value of 5 or 6 dry, 4 or 5 moist, and chroma of 2 to 4. Textures are commonly stratified loam, silt loam, clay loam, and silty clay loam with 20 to 35 percent clay, and less than 15 percent fine and coarser sand. Exchangeable sodium is typically less than 15 percent, but may be slightly higher in some pedons. Electrical conductivity ranges from 0 to 8 millimhos per centimeter. Reaction is moderately alkaline or strongly alkaline.

COMPETING SERIES: There are no competing series in this Family.

GEOGRAPHIC SETTING: Emigha soils are on upland toeslopes and low terraces. They formed in alluvium derived primarily from shale. Slopes are 0 to 4 percent. Elevations are 3,600 to 5,200 feet. The mean annual precipitation ranges from 10 to 14 inches, half of which falls as rain and snow from late March through June. The mean annual air temperature ranges from 44 to 50 degrees F. The frost-free season is about 105 to 130 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Absted, Arvada, Kishona and Skilak soils. Absted and Arvada soils are fine and have argillic horizons. Kishona soils are fine-loamy and lack cambic horizons. Skilak soils lack cambic horizons.

DRAINAGE AND PERMEABILITY: Well drained; medium runoff; moderate to slow permeability.

USE AND VEGETATION: These soils are utilized for rangeland, wildlife habitat, and for limited hayland and pasture. The native vegetation is mainly western wheatgrass, needleandthread, blue grama and green needlegrass. Alfalfa and winter wheat are the principle crops.

DISTRIBUTION AND EXTENT: Emigha soils occur in northeast Wyoming. The series is of limited extent.

MLRA OFFICE RESPONSIBLE: Bismarck, North Dakota

SERIES ESTABLISHED: Campbell County, Wyoming, Southern Part; 1995.

REMARKS: Diagnostic horizons and features recognized in this pedon are: Ochric epipedon - 0 to 1 inch (A horizon); Cambic horizon - 1 to 19 inches (Bw1, Bw2 horizons); Ustifluventic subgroup - Organic carbon at a depth of 125 centemeters is 0.3 percent. (Lab. sample S91WY-5-004)

SIR- WY9449

LRR=G

National Cooperative Soil Survey
U.S.A.

LOCATION ARVADA WY+CO KS MT NE SD

Established Series
MCS/JWW/CJH
12/2003

ARVADA SERIES

The Arvada series consists of very deep, well drained soils formed in alluvium and colluvium derived from sodic shale. Arvada soils are on alluvial fans, fan remnants, fan terraces and hillslopes. Slopes are 0 to 25 percent. The mean annual precipitation is about 12 inches, and the mean annual air temperature is about 46 degrees F.

TAXONOMIC CLASS: Fine, smectitic, mesic Ustertic Natrargids

TYPICAL PEDON: Arvada fine sandy loam-rangeland. (Colors are for dry soil unless otherwise stated)

E--0 to 4 inches; light gray (10YR 7/2) fine sandy loam, grayish brown (10YR 5/2) moist; moderate very thin platy structure parting to moderate very fine granular; soft, very friable, nonsticky and nonplastic; many fine and very fine roots; slightly alkaline (pH 7.8); abrupt smooth boundary. (0 to 8 inches thick)

Btn--4 to 14 inches; brown (10YR 5/3) clay, brown (10YR 4/3) moist; moderate medium columnar structure parting to moderate medium angular blocky; extremely hard, firm, sticky and very plastic; common medium roots; many prominent clay films on faces of peds and in root channels; very strongly alkaline (pH 9.2); ESP is 20 percent; clear smooth boundary. (3 to 14 inches thick)

Btkn--14 to 20 inches; brown (10YR 5/3) clay loam, brown (10YR 4/3) moist; weak medium subangular blocky structure; extremely hard, firm, sticky and very plastic; few faint clay films on faces of peds and in root channels; strongly effervescent, few fine segregations of calcium carbonate in thin seams and streaks; strongly alkaline (pH 9.0); 20 percent exchangeable sodium; gradual smooth boundary. (0 to 17 inches thick)

Bkny--20 to 60 inches; light yellowish brown (2.5Y 6/3) clay loam, light olive brown (2.5Y 5/3) moist; massive; hard, friable, sticky and plastic; violently effervescent, common medium soft masses of calcium carbonate and gypsum as crystals in thin seams and as filaments or threads; strongly alkaline (pH 8.8); 20 percent exchangeable sodium.

TYPE LOCATION: Sheridan County, Wyoming; 650 feet south and 200 feet west of the northeast corner of sec. 29, T. 55 N., R. 78 W. 44 degrees 43 minutes 7 seconds north latitude and 106 degrees 15 minutes 54 seconds west longitude.

RANGE IN CHARACTERISTICS: Depth to effervescent material ranges from 0 to 19 inches. Depth to layers with greater than 15 percent exchangeable sodium is 4 to 10 inches. The depth to the base of the Bt horizon is 15 inches or more. A thin A horizon occurs in some pedons. A light colored platy E horizon is generally present but is absent in some pedons. Gravel is typically less than 5 percent but ranges from 0 to 15 percent. The moisture control section is usually dry for 60 consecutive days during

the 90 day period following the summer solstice. The mean annual soil temperature is 47 to 53 degrees F., and the soil temperature at a depth of 20 inches is 41 degrees F. or more for 175 to 195 days. The soil has an aridic moisture regime that borders on ustic.

The E and A horizons have hue of 10YR, 2.5Y or 5Y, value of 4 to 7, 4 or 5 moist, and chroma of 2 to 4. Texture is fine sandy loam, loam, silt loam, clay loam or very fine sandy loam. Reaction ranges from neutral through strongly alkaline. EC ranges from 0 to 4 mmhos/cm.

The Btn horizon has hue of 7.5YR, 10YR, 2.5Y or 5Y, value of 4 to 6 dry, 4 or 5 moist, and chroma of 2 to 4. Texture is clay, clay loam, silty clay or silty clay loam and has 35 to 60 percent clay, 10 to 50 percent silt, and 5 to 45 percent sand. This horizon is strongly alkaline or very strongly alkaline (pH 8.8 to 10.0), has 15 to 34 percent exchangeable sodium, and an EC of 4 to 16 mmhos/cm. Some pedons when buffered by gypsum are moderately alkaline. The Btkn horizon, when present, has a calcium carbonate equivalent of 3 to 12 percent and an exchangeable sodium percent of 10 to 30. A thin Bt horizon is present above the Btn in some pedons. Some pedons have a Btkny horizon.

The Bkny horizon has hue of 7.5YR, 10YR or 2.5Y, value of 5 or 6 dry, 4 or 5 moist. Textures are clay, clay loam, silty clay or silty clay loam. Reaction ranges from strongly alkaline or very strongly alkaline (pH 8.6 to 10.0). This horizon contains 4 to 15 percent calcium carbonate equivalent. Some pedons when buffered by gypsum are moderately alkaline. Exchangeable sodium typically ranges from 10 to 30 percent but decreases with increasing depth. Electrical conductivity is 4 to 16 mmhos/cm. Some pedons have a C horizon.

Some pedons have a C horizon below 40 inches. It has properties similar to those of the Bkny horizon.

COMPETING SERIES: There are no competing series.

GEOGRAPHIC SETTING: The Arvada soils are on alluvial fans, fan remnants, terraces and hillslopes. The soils formed in moderately fine textured alluvium and colluvium derived from sedimentary rocks. Slopes range from 0 to 25 percent. Elevations range from 2,600 to 6,000 feet. The average annual precipitation is about 12 inches but ranges from 9 to 14 inches with about half the precipitation occurring during April, May, and early June. The mean annual air temperature is about 43 to 53 degrees F., and the mean summer temperature is 63 degrees F. The frost-free season is estimated to range from 100 to 160 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Absted, Bidman, Parmleed, Renohill and Ulm soils. Absted soils have less than 15 percent sodium in the upper part of the argillic horizon. Bidman, Parmleed, Renohill and Ulm soils lack natric horizons.

DRAINAGE AND PERMEABILITY: Well drained; high or very high runoff; very slow permeability.

USE AND VEGETATION: Rangeland and wildlife habitat. Native vegetation is alkali sacaton, Gardner saltbush, western wheatgrass, and scattered greasewood.

DISTRIBUTION AND EXTENT: Eastern Wyoming, eastern Colorado and parts of adjacent states. The series is extensive.

MLRA OFFICE RESPONSIBLE: Bismarck, North Dakota

SERIES ESTABLISHED: Sheridan County, Wyoming; 1932.

REMARKS: Diagnostic horizons and features recognized in this pedon are: Albic horizon - 0 to 4 inches (E)

Natric horizon - 4 to 20 inches (Btn, Btkn)

SIR- WY1130

LRR- G

National Cooperative Soil Survey
U.S.A.

LOCATION HAVERDAD WY+MT UT

Established Series
Rev. JEI/MCS/SSP
06/2002

HAVERDAD SERIES

The Haverdad series consists of very deep, well drained soils formed in stratified alluvium on flood plains and low terraces. Permeability is moderate. Slopes range from 0 to 6 percent. The mean annual precipitation is about 11 inches, and the mean annual temperature is about 45 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, calcareous, mesic Ustic Torrifluvents

TYPICAL PEDON: Haverdad loam - utilized as rangeland. (Colors are for dry soil unless otherwise stated)

A--0 to 4 inches; pale brown (10YR 6/3) loam, dark grayish brown (10YR 4/2) moist; moderate medium subangular structure parting to weak fine granular; slightly hard, friable, slightly sticky and slightly plastic; many fine roots throughout; carbonates are disseminated throughout; slightly effervescent; moderately alkaline (pH 8.0); gradual smooth boundary. (2 to 8 inches thick)

C1--4 to 14 inches; pale brown (10YR 6/3) loam, brown (10YR 4/3) moist; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine roots throughout; carbonates are disseminated throughout; slightly effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

C2--14 to 30 inches; pale brown (10YR 6/3) loam, stratified with fine sandy loam, sand loam, clay loam, and silt loam, brown (10YR 4/3) moist; weak fine and medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine and very fine roots throughout; carbonates are disseminated throughout; slightly effervescent; strongly alkaline (pH 8.6); gradual smooth boundary.

C3--30 to 60 inches; pale brown (10YR 6/3) clay loam, stratified with fine sandy loam, loam, silt loam, and silty clay loam, brown (10YR 5/3) moist; weak fine and medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine and very fine roots throughout; carbonates are disseminated throughout; slightly effervescent; strongly alkaline (pH 8.6); gradual smooth boundary.

TYPE LOCATION: Niobrara County, Wyoming; about 2,600 feet north and 750 feet east of the southwest corner of Sec. 12, T 38 N, R 65 W. lat. 43 degrees 17 minutes 2 seconds north and long. 104 degrees 36 minutes 54 seconds west.

RANGE IN CHARACTERISTICS:
Soil moisture: The soil is dry in the moisture control section more than half the time cumulative that the soil temperature at a depth of 20 inches is 41 degrees F. or more. This soil is moist for 60 consecutive days when the soil temperature at 20 inches is 41 degrees F., which occurs about April 21-27, but is dry in all parts of the moisture control section for at least 60 consecutive days from July 15 to October 25

and for at least 90 cumulative days during this period.

Mean annual soil temperature: 48 to 53 degrees F. and the soil temperature at a depth of 20 inches is 41 degrees F. or more for 175 to 195 days.

Organic carbon content: .5 to 1.0 percent and decreases irregularly with depth
Rock fragments: 0 to 15 percent gravel
EC (mmhos/cm): 0 to 8 mmhos throughout but where irrigated some soils may range up to 16 mmhos
Calcium sulfate occurs in some pedons.
The soil is typically calcareous to the surface, but some pedons are leached as deep as 20 inches.

A horizon:
Hue: 10YR or 2.5Y
Value: 4 through 6 dry, 3 through 5 moist
Chroma: 2 through 4 dry or moist
Texture: loam, clay loam, silt loam, silty clay loam, very fine sandy loam, fine sandy loam, sandy loam
Reaction: slightly alkaline through strongly alkaline

Some pedons have an AC horizon.

C horizon:
Hue: 10YR or 2.5Y
Value: 5 through 7 dry, 4 to 6 moist
Chroma: 2 through 4 dry or moist
Texture: variable but when averaged is loam or light clay loam with 18 to 35 percent clay
Calcium carbonate equivalent: 1 to 15 percent which changes erratically between strata
Reaction: slightly alkaline through strongly alkaline

COMPETING SERIES: These are the Hamburn, Manikan, San Mateo, and Suwanee series.

Hamburn: have pedogenic accumulations of salt and SARs greater than 13
Manikan, and Suwanee: have hue of 7.5YR or redder
San Mateo: have soil moisture control sections that are drier during April, May, and June

GEOGRAPHIC SETTING:
Parent material: alluvium from mixed sources
Landform: floodplains and low terraces
Elevations: 3,500 to 6,500 feet
Slopes: 0 to 6 percent
Mean annual precipitation: about 11 inches, ranging 10 to 17, with over half of annual precipitation falling in April, May, and June
Mean annual temperature: about 45 degrees F. and ranges from 43 to 52 degrees F.
Frost-free period: 105 to 130 days

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Arvada, Forkwood, Kishona, and Shingle soils. Arvada soils have a natric horizon. Forkwood soils have an argillic horizon. Kishona soils lack stratification. Shingle soils have bedrock at a depth of 4 to 20 inches.

DRAINAGE AND PERMEABILITY: Well drained; slow runoff; moderate permeability. Flooding for brief periods occurs during spring runoff and after thunder showers.

USE AND VEGETATION: These soils are used principally for grazing. Principal native vegetation is big sagebrush, western wheatgrass, greasewood, and annual grasses and forbs.

DISTRIBUTION AND EXTENT: Big Horn Basin, central, eastern Wyoming, Colorado, and Utah.

MLRA OFFICE RESPONSIBLE: Lakewood, Colorado

SERIES ESTABLISHED: Washakie County, Wyoming; 1980.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - 0 to 6 inches (A)

The type location for this series was moved from Washakie County, Wyoming to its current location in Niobrara County, Wyoming to better reflect the moisture regime concept, June 2002.

National Cooperative Soil Survey
U.S.A.

LOCATION KISHONA WY+MT

Established Series
CAP-GFK-CJH
11/2005

KISHONA SERIES

The Kishona series consists of very deep, well drained soils formed in alluvium on fan aprons, alluvial fans, fan remnants, hills, ridges and terraces. Permeability is moderate. Slopes range from 0 to 30 percent. The average annual precipitation is about 12 inches, and the mean annual temperature is about 46 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, calcareous, mesic Ustic Torriorthents

TYPICAL PEDON: Kishona loam - in rangeland. (Colors are for dry soil unless otherwise stated)

A--0 to 4 inches; brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; moderate medium and fine granular structure; soft, very friable, slightly sticky and nonplastic; common fine roots throughout; slightly alkaline; clear smooth boundary. (1 to 6 inches thick)

Bk--4 to 24 inches; very pale brown (10YR 7/3) silty clay loam, brown (10YR 5/3) moist; weak medium and coarse angular structure; hard, friable, slightly sticky and slightly plastic; few fine and very fine roots throughout; common fine masses of carbonates; strongly effervescent; strongly alkaline; gradual smooth boundary. (0 to 30 inches thick)

C--24 to 60 inches; pale brown (10YR 6/3) loam, brown (10YR 5/3) moist; massive; slightly hard, friable, slight sticky and nonplastic; few very fine roots throughout; carbonates are disseminated throughout; slightly effervescent; strongly alkaline.

TYPE LOCATION: Niobrara County, Wyoming; about 2,500 feet south and 2,500 feet east of the northwest corner of sec. 30, T. 40 N., R. 66 W. lat. 43 degrees 24 minutes 59 seconds north and long. 104 degrees 49 minutes 42 seconds west.

RANGE IN CHARACTERISTICS: Rock fragments ranges from 0 to 15 percent. The mean annual soil temperature ranges from 48 to 53 degrees F., and the soil temperature at a depth of 20 inches is 41 degrees F. or more for 190 to 202 days. The depth to carbonates ranges from 0 to 10 inches. Saline phases are recognized. The soil is dry in the moisture control section more than half the time cumulative that the soil temperature at a depth of 20 inches is 41 degrees F. and is never moist in some or all parts for as long as 90 consecutive days when the soil temperature at a depth of 20 inches is 48 degrees F. or more. This soil is moist for 60 consecutive days when the soil temperature at a depth of 20 inches is 41 degrees F., which occurs April 21-27, but is dry in all parts of the moisture control section for at least 60 consecutive days from July 15 to October 25 and for at least 90 cumulative days during that period.

The A horizon has hue of 2.5Y or 10YR, value of 4 to 6 dry, 3 to 5 moist, and chroma of 2 to 4. It is very fine sandy loam, fine sandy loam, loam, silt loam, silty clay loam or clay loam. It is neutral to moderately alkaline.

Some pedons have a thin, noncalcareous Bw horizon that has its base at a depth of less than 10 inches.

The Bk and C horizons have hue of 5Y, 2.5Y or 10YR, value of 5 to 7 dry, 4 or 5 moist, and chroma of 2 to 4. They are loam, clay loam or silty clay loam and have 20 to 35 percent clay, 20 to 55 percent silt, and 15 to 35 percent fine sand or coarser. Reaction ranges from moderately alkaline to very strongly alkaline. Carbonates in the Bk horizon range from 3 to 14 percent and occur as accumulations in small masses, streaks or seams that decrease with increasing depth, or they are disseminated throughout. The Bk horizon has an EC of 0 to 8 mmhos/cm.

COMPETING SERIES: These are the El Rancho, Mikim, Neville, Paradox, Pojoaque, Shavano, Thedalund, Theedle and Tsosie series (El Rancho, Neville, Pogoaque and Shavano are presumed to be competing pending an update of the classification). El Rancho, Neville, Paradox and Pojoaque soils have hue of 7.5YR or redder. Mikim soils are moist in some or all parts of the moisture control section for at least 90 cumulative days when the soil at a depth of 20 inches is 41 degrees F. or more and are moist for 45 consecutive days following July 15. Pojoaque soils have 15 to 35 percent rock fragments. Shavano, Theedle and Thedalund soils have bedrock at a depth of 20 to 40 inches. Tsosie soils are stratified in the C horizon and are dry in the moisture control section between April 15 and July 1.

GEOGRAPHIC SETTING: Kishona soils are on dissected alluvial fans, fan remnants, fan aprons, hills, ridges and terraces. Slopes are typically 0 to 6 percent but range up to 30 percent on dissected slopes. The soils formed in alluvium derived from sandstones and shales. Elevation is 3,500 to 6,700 feet. The average annual precipitation ranges from 10 to 14 inches with over one-half falling in April, May and June and less than one inch falling in each month of July, August, September, and October. The mean annual air temperature is about 45 degrees F. but ranges from 43 to 51 degrees F. The frost-free season is about 105 to 130 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Theedle soils and the Cushman, Forkwood, Haverdad and Shingle soils. Theedle and Cushman soils are on shoulder slopes and summits of hills and ridges. Cushman and Forkwood soils have an argillic horizon. Forkwood soils are on more stable positions. Haverdad soils have a stratified control section in which the organic carbon decreases irregularly with increasing depth. They are on flood plains. Shingle soils have bedrock at a depth of 4 to 20 inches. They are on ridges and scarps.

DRAINAGE AND PERMEABILITY: Well drained; slow and medium runoff; moderate permeability.

USE AND VEGETATION: These soils support native vegetation utilized by domestic livestock and wildlife. Where irrigation water is available, they are irrigated and cropped to small grains and used for hay and pastureland. Native vegetation at the type location is Gardner saltbush, western wheatgrass, bottlebrush squirreltail, and bud sagebrush.

DISTRIBUTION AND EXTENT: Big Horn Basin, central Wyoming, Powder River Basin, northeastern Wyoming and western Colorado.

MLRA OFFICE RESPONSIBLE: Bismarck, North Dakota

SERIES ESTABLISHED: Washakie County, Wyoming; 1978.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - 0 to 4 inches (A horizon)

SIR- WY0944

LRR- G

National Cooperative Soil Survey
U.S.A.

Appendix B

ENERGY LABORATORIES, INC. • P.O. Box 5688 • 3161 East Lyndale Ave. • Helena, MT 59604
877-472-0711 • 406-442-0711 • 406-442-0712 fax • helena@energylab.com

Date: *04-Jun-07*

CLIENT: Williams Production RMT
Project: Beaver Creek Sec 20 Flying T
Sample Delivery Group: H07050254

CASE NARRATIVE

Sample Flying T 0-6-001 was submitted to DCM Science Laboratory in Wheat Ridge, CO for Clay Mineralogy. Attached is report.

DCM Science Laboratory, Inc.
12421 W. 49th Avenue, Unit #6
Wheat Ridge, CO 80033 - (303) 463-8270

Quantitative Clay Analysis (XRD)

Client:
Energy Laboratories, Inc.
3161 E. Lyndale
Helena, MT 59601

Analysis Date:	5-25-07
Reporting Date:	5-31-07
Receipt Date:	5-25-07
Client Job No.:	H07050254
Project Title:	None Given
DCMSL Project:	ELAB19

Client Sample No.:	**H07050254 001**
Clay Fraction <2μm	
Smectite	46
Illite	34
Kaolinite	20

An oriented clay mount (<2μm) was prepared for x-ray diffraction and scanned over a range of 3° to 45° 2Θ using CuKα radiation, 40kV, 25mA. The mount was analyzed air dried (RH ~25%) and glycolated. Clay concentrations are based on peak areas and intensity factors measured in-house on known standards or computer calculated.

Ron Schott

Ron Schott, Analyst

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LABORATORY ANALYTICAL REPORT

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Flying T
Workorder: H07050254

Report Date: 06/03/07
Date Received: 05/22/07

		Analysis		pH-SatPst	COND	Percent Sat	SAR	Ca-SatPst	Mg-SatPst	Na-SatPst	K-SatPst	SO4-SatPst	Sand	Silt
		Units		s_u_	mmhos/cm	%	unitless	meq/l	meq/l	meq/l	meq/l	meq/L	%	%
Sample ID	**Client Sample ID**	**Up**	**Low**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
H07050254-001	Flying T 0-6"	0	0	7.3	4.78	55.6	6.6	21.7	10.2	26.3	1.48	60.2	31	28
H07050254-002	Flying T 6-12"	0	0	7.9	9.16	54.0	16	21.1	18.0	72.6	0.85	121	31	48
H07050254-003	Flying T 12-24"	0	0	8.2	13.2	59.4	24	19.9	33.7	126	0.79	192	33	45
H07050254-004	Flying T 24-36"	0	0	8.2	12.3	59.6	23	24.1	32.6	123	0.65	191	29	46
H07050254-005	Flying T 36-48"	0	0	8.0	10.9	52.0	18	22.9	31.6	91.9	0.59	156	35	42
H07050254-006	Flying T 48-72"	0	0	7.9	10.9	48.8	18	23.5	31.2	92.5	0.53	157	45	34

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LABORATORY ANALYTICAL REPORT

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Flying T
Workorder: H07050254

Report Date: 06/03/07
Date Received: 05/22/07

		Analysis		Clay	Texture	OM-WB	CEC	Lime	Na-Ext	Exch Na	ESP
		Units		%	unitless	%	meq/100g	%	meq/100g	meq/100g	%
Sample ID	**Client Sample ID**	**Up**	**Low**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
H07050254-001	Flying T 0-6"	0	0	41	C	3.51	26.2	3.3	2.88	1.4	5.4
H07050254-002	Flying T 6-12"	0	0	21	L	1.42	22.1	3.4	7.14	3.2	15
H07050254-003	Flying T 12-24"	0	0	22	L	0.67	22.1	4.2	11.7	4.3	19
H07050254-004	Flying T 24-36"	0	0	25	L	0.94	21.9	4.7	11.1	3.7	17
H07050254-005	Flying T 36-48"	0	0	23	L	0.91	20.0	4.6	8.36	3.6	18
H07050254-006	Flying T 48-72"	0	0	21	L	0.64	18.9	4.0	7.64	3.1	16

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Flying T

Report Date: 06/03/07
Work Order: H07050254

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASA15-5									Batch: 3344
Sample ID: H07050248-010ADUP	Sample Duplicate				Run: MISC SOILS_070601H			05/29/07 14:19	
Sand	34	%	1.0				2.9	30	
Silt	43	%	1.0				2.4	30	
Clay	23	%	1.0				0.0	30	
Sample ID: LCS	Laboratory Control Sample				Run: MISC SOILS_070601H			05/29/07 14:19	
Sand	42	%	1.0	117	70	130			
Silt	33	%	1.0	80	70	130			
Clay	25	%	1.0	109	70	130			
Method: ASA29-3									Batch: 3345
Sample ID: H07050248-010ADUP	Sample Duplicate				Run: MISC SOILS_070529B			05/29/07 12:06	
Organic Matter	2.56	%	0.020				1.3	30	
Sample ID: LCS0705291206	Laboratory Control Sample				Run: MISC SOILS_070529B			05/29/07 12:06	
Organic Matter	2.02	%	0.020	102	70	130			
Sample ID: MBLK0705291206	Method Blank				Run: MISC SOILS_070529B			05/29/07 12:06	
Organic Matter	0.07	%	0.009						
Method: ASAM10-3									Batch: 3340
Sample ID: H07050248-010ADUP	Sample Duplicate				Run: MISC SOILS_070601H			05/29/07 14:19	
Conductivity, sat. paste	0.500	mmhos/cm	0.010				18	30	
Sample ID: LCS	Laboratory Control Sample				Run: MISC SOILS_070601J			05/29/07 14:19	
Conductivity, sat. paste	5.57	mmhos/cm	0.010	118	70	130			
Method: ASAM10-3.2									Batch: 3340
Sample ID: H07050248-010ADUP	Sample Duplicate				Run: MISC SOILS_070601H			05/29/07 14:19	
pH, sat. paste	7.30	s.u.	0.10				0.0	30	
Sample ID: LCS	Laboratory Control Sample				Run: MISC SOILS_070601J			05/29/07 14:19	
pH, sat. paste	7.20	s.u.	0.10	97	80	120			
Method: Calculation									Batch: R37691
Sample ID: LCS	Laboratory Control Sample				Run: MISC SOILS_070601J			05/29/07 14:19	
Sodium Adsorption Ratio (SAR)	6.8	unitless	0.010	96	80	120			

Qualifiers:

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ND - Not detected at the reporting limit.

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Flying T

Report Date: 06/03/07
Work Order: H07050254

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B								Analytical Run: ICP1-HE_070601A	
Sample ID: ICV	Initial Calibration Verification Standard								06/01/07 08:22
Calcium	51.1	mg/L	1.0	102	90	110			
Magnesium	49.0	mg/L	1.0	98	90	110			
Sodium	51.3	mg/L	1.0	103	90	110			
Calcium, sat. paste	2.55	meq/L	0.050	102	90	110			
Magnesium, sat. paste	4.03	meq/L	0.082	98	90	110			
Sodium, sat. paste	2.23	meq/L	0.044	103	90	110			
Sample ID: CCV	Continuing Calibration Verification Standard								06/01/07 08:30
Sulfate	791	mg/L	1.0	106	90	110			
Calcium	266	mg/L	1.0	106	90	110			
Magnesium	259	mg/L	1.0	104	90	110			
Potassium	48.6	mg/L	1.0	97	90	110			
Sodium	255	mg/L	1.0	102	90	110			
Calcium, sat. paste	13.3	meq/L	0.050	106	90	110			
Magnesium, sat. paste	21.3	meq/L	0.082	104	90	110			
Sodium, sat. paste	11.1	meq/L	0.044	102	90	110			
Potassium, sat. paste	1.24	meq/L	0.026	97	90	110			
Sulfate, sat. paste	16.5	meq/L	0.021	106	90	110			
Sample ID: CCB	Continuing Calibration Blank								06/01/07 08:32
Sulfate	0.0909	mg/L	1.0						
Calcium	0.00890	mg/L	1.0						
Magnesium	0.00740	mg/L	1.0						
Potassium	0.267	mg/L	1.0						
Sodium	0.358	mg/L	1.0						
Calcium, sat. paste	0.000444	meq/L	0.050						
Magnesium, sat. paste	0.000609	meq/L	0.082						
Sodium, sat. paste	0.0156	meq/L	0.044						
Potassium, sat. paste	0.00684	meq/L	0.026						
Sulfate, sat. paste	0.00189	meq/L	0.021						
Sample ID: CCV	Continuing Calibration Verification Standard								06/01/07 09:02
Calcium	267	mg/L	1.0	107	90	110			
Magnesium	255	mg/L	1.0	102	90	110			
Potassium	47.0	mg/L	1.0	94	90	110			
Sodium	252	mg/L	1.0	101	90	110			
Calcium, sat. paste	13.3	meq/L	0.050	107	90	110			
Magnesium, sat. paste	21.0	meq/L	0.082	102	90	110			
Sodium, sat. paste	11.0	meq/L	0.044	101	90	110			
Potassium, sat. paste	1.20	meq/L	0.026	94	90	110			

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Flying T

Report Date: 06/03/07
Work Order: H07050254

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B								Analytical Run: ICP1-HE_070601A	
Sample ID: CCB	Continuing Calibration Blank							06/01/07 09:04	
Sulfate	0.0909	mg/L	1.0						
Calcium	0.00890	mg/L	1.0						
Magnesium	0.00740	mg/L	1.0						
Potassium	0.255	mg/L	1.0						
Sodium	0.264	mg/L	1.0						
Calcium, sat. paste	0.000444	meq/L	0.050						
Magnesium, sat. paste	0.000609	meq/L	0.082						
Sodium, sat. paste	0.0115	meq/L	0.044						
Potassium, sat. paste	0.00653	meq/L	0.026						
Sulfate, sat. paste	0.00189	meq/L	0.021						
Sample ID: CCV	Continuing Calibration Verification Standard							06/01/07 09:34	
Calcium	258	mg/L	1.0	103	90	110			
Magnesium	261	mg/L	1.0	104	90	110			
Potassium	47.6	mg/L	1.0	95	90	110			
Sodium	254	mg/L	1.0	102	90	110			
Calcium, sat. paste	12.9	meq/L	0.050	103	90	110			
Magnesium, sat. paste	21.4	meq/L	0.082	104	90	110			
Sodium, sat. paste	11.1	meq/L	0.044	102	90	110			
Potassium, sat. paste	1.22	meq/L	0.026	95	90	110			
Sample ID: CCB	Continuing Calibration Blank							06/01/07 09:36	
Sulfate	0.0909	mg/L	1.0						
Calcium	0.00890	mg/L	1.0						
Magnesium	0.00740	mg/L	1.0						
Potassium	0.270	mg/L	1.0						
Sodium	0.311	mg/L	1.0						
Calcium, sat. paste	0.000444	meq/L	0.050						
Magnesium, sat. paste	0.000609	meq/L	0.082						
Sodium, sat. paste	0.0135	meq/L	0.044						
Potassium, sat. paste	0.00691	meq/L	0.026						
Sulfate, sat. paste	0.00189	meq/L	0.021						
Sample ID: CCV	Continuing Calibration Verification Standard							06/01/07 10:06	
Calcium	247	mg/L	1.0	99	90	110			
Magnesium	254	mg/L	1.0	102	90	110			
Potassium	47.2	mg/L	1.0	94	90	110			
Sodium	243	mg/L	1.0	97	90	110			
Calcium, sat. paste	12.3	meq/L	0.050	99	90	110			
Magnesium, sat. paste	20.9	meq/L	0.082	102	90	110			
Sodium, sat. paste	10.6	meq/L	0.044	97	90	110			

Qualifiers:

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Flying T

Report Date: 06/03/07
Work Order: H07050254

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B									Analytical Run: ICP1-HE_070601A
Sample ID: CCV	Continuing Calibration Verification Standard								06/01/07 10:06
Potassium, sat. paste	1.21	meq/L	0.026	94	90	110			
Sample ID: CCB	Continuing Calibration Blank								06/01/07 10:08
Sulfate	0.0909	mg/L	1.0						
Calcium	0.00890	mg/L	1.0						
Magnesium	0.00740	mg/L	1.0						
Potassium	0.255	mg/L	1.0						
Sodium	0.332	mg/L	1.0						
Calcium, sat. paste	0.000444	meq/L	0.050						
Magnesium, sat. paste	0.000609	meq/L	0.082						
Sodium, sat. paste	0.0144	meq/L	0.044						
Potassium, sat. paste	0.00651	meq/L	0.026						
Sulfate, sat. paste	0.00189	meq/L	0.021						
Sample ID: CCV	Continuing Calibration Verification Standard								06/01/07 10:43
Calcium	247	mg/L	1.0	99	90	110			
Magnesium	248	mg/L	1.0	99	90	110			
Potassium	46.6	mg/L	1.0	93	90	110			
Sodium	240	mg/L	1.0	96	90	110			
Calcium, sat. paste	12.3	meq/L	0.050	99	90	110			
Magnesium, sat. paste	20.4	meq/L	0.082	99	90	110			
Sodium, sat. paste	10.4	meq/L	0.044	96	90	110			
Potassium, sat. paste	1.19	meq/L	0.026	93	90	110			
Sample ID: CCB	Continuing Calibration Blank								06/01/07 10:46
Sulfate	0.0909	mg/L	1.0						
Calcium	0.00890	mg/L	1.0						
Magnesium	0.00740	mg/L	1.0						
Potassium	0.251	mg/L	1.0						
Sodium	0.396	mg/L	1.0						
Calcium, sat. paste	0.000444	meq/L	0.050						
Magnesium, sat. paste	0.000609	meq/L	0.082						
Sodium, sat. paste	0.0172	meq/L	0.044						
Potassium, sat. paste	0.00643	meq/L	0.026						
Sulfate, sat. paste	0.00189	meq/L	0.021						
Method: SW6010B									Batch: 3340
Sample ID: LCS-3340	Laboratory Control Sample				Run: ICP1-HE_070601A				06/01/07 08:35
Calcium	560	mg/L	1.0	114	80	120			
Magnesium	154	mg/L	1.0	103	80	120			
Potassium	29.1	mg/L	1.0	93	80	120			

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Flying T

Report Date: 06/03/07
Work Order: H07050254

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B									Batch: 3340
Sample ID: LCS-3340	Laboratory Control Sample				Run: ICP1-HE_070601A				06/01/07 08:35
Sodium	703	mg/L	1.0	101	80	120			
Calcium, sat. paste	27.9	meq/L	0.050	114	80	120			
Magnesium, sat. paste	12.7	meq/L	0.082	105	80	120			
Sodium, sat. paste	30.6	meq/L	0.044	101	80	120			
Potassium, sat. paste	0.744	meq/L	0.026	94	80	120			
Sample ID: H07050248-010ADup	Sample Duplicate				Run: ICP1-HE_070601A				06/01/07 09:10
Calcium	80.8	mg/L	1.0				1.3	30	
Magnesium	12.9	mg/L	1.0				9.9	30	
Potassium	11.6	mg/L	1.0				3.4	30	
Sodium	19.8	mg/L	1.0				8.8	30	
Calcium, sat. paste	4.03	meq/L	0.050				1.3	30	
Magnesium, sat. paste	1.06	meq/L	0.082				9.9	30	
Sodium, sat. paste	0.863	meq/L	0.044				8.8	30	
Potassium, sat. paste	0.297	meq/L	0.026				3.4	30	
Sample ID: H07050254-005ADup	Sample Duplicate				Run: ICP1-HE_070601A				06/01/07 10:35
Sulfate	7240	mg/L	1.0				3.7	30	
Calcium	458	mg/L	1.0				0.4	30	
Magnesium	356	mg/L	1.0				7.7	30	
Potassium	23.0	mg/L	1.0				0.1	30	
Sodium	2050	mg/L	1.0				2.9	30	
Calcium, sat. paste	22.9	meq/L	0.050				0.4	30	
Magnesium, sat. paste	29.3	meq/L	0.082				7.7	30	
Sodium, sat. paste	89.3	meq/L	0.044				2.9	30	
Potassium, sat. paste	0.588	meq/L	0.026				0.1	30	
Sulfate, sat. paste	151	meq/L	0.021				3.7	30	

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Flying T

Report Date: 06/03/07
Work Order: H07050254

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B								Analytical Run: ICP1-HE_070531A	
Sample ID: ICV	Initial Calibration Verification Standard								05/31/07 08:55
Sodium	51.3	mg/kg	1.0	103	90	110			
Cation Exchange Capacity	4.46	meq/100g	0.087	103	90	110			
Sample ID: CCV	Continuing Calibration Verification Standard								05/31/07 09:03
Sodium	249	mg/kg	1.0	99	90	110			
Cation Exchange Capacity	21.6	meq/100g	0.087	103	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/31/07 09:05
Sodium	0.160	mg/kg	1.0						
Cation Exchange Capacity	0.0139	meq/100g	0.087						
Sample ID: CCV	Continuing Calibration Verification Standard								05/31/07 09:35
Sodium	238	mg/kg	1.0	95	90	110			
Cation Exchange Capacity	20.7	meq/100g	0.087	99	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/31/07 09:37
Sodium	0.164	mg/kg	1.0						
Cation Exchange Capacity	0.0143	meq/100g	0.087						
Sample ID: CCV	Continuing Calibration Verification Standard								05/31/07 10:07
Sodium	231	mg/kg	1.0	92	90	110			
Cation Exchange Capacity	20.1	meq/100g	0.087	96	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/31/07 10:09
Sodium	0.300	mg/kg	1.0						
Cation Exchange Capacity	0.0261	meq/100g	0.087						
Sample ID: CCV	Continuing Calibration Verification Standard								05/31/07 10:39
Sodium	234	mg/kg	1.0	93	90	110			
Cation Exchange Capacity	20.3	meq/100g	0.087	97	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/31/07 10:41
Sodium	0.223	mg/kg	1.0						
Cation Exchange Capacity	0.0194	meq/100g	0.087						
Sample ID: CCV	Continuing Calibration Verification Standard								05/31/07 11:11
Sodium	235	mg/kg	1.0	94	90	110			
Cation Exchange Capacity	20.4	meq/100g	0.087	97	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/31/07 11:13
Sodium	0.252	mg/kg	1.0						
Cation Exchange Capacity	0.0219	meq/100g	0.087						

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Flying T

Report Date: 06/03/07
Work Order: H07050254

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B									Batch: 3341
Sample ID: LCS-3341	Laboratory Control Sample				Run: ICP1-HE_070531A				05/31/07 09:08
Sodium	294	mg/kg	1.0	94	80	120			
Cation Exchange Capacity	25.5	meq/100g	0.087	94	80	120			
Sample ID: H07050248-015AMS	Sample Matrix Spike				Run: ICP1-HE_070531A				05/31/07 10:01
Sodium	344	mg/kg	1.0	97	70	130			
Cation Exchange Capacity	29.9	meq/100g	0.087	97	70	130			
Sample ID: H07050248-015AMSD	Sample Matrix Spike Duplicate				Run: ICP1-HE_070531A				05/31/07 10:04
Sodium	344	mg/kg	1.0	97	70	130	0.0	30	
Cation Exchange Capacity	29.9	meq/100g	0.087	97	70	130	0.0	30	
Sample ID: H07050254-003ADup	Sample Duplicate				Run: ICP1-HE_070531A				05/31/07 11:00
Sodium	250	mg/kg	1.0				1.7	30	
Cation Exchange Capacity	21.7	meq/100g	0.087				1.7	30	
Method: SW6010B									Batch: 3342
Sample ID: H07050248-015AMS	Sample Matrix Spike				Run: ICP1-HE_070529A				05/29/07 13:12
Sodium	127	mg/kg	1.0	80	80	120			
Sodium, Extractable	5.52	meq/100g	0.044	81	80	120			
Sample ID: H07050248-015AMSD	Sample Matrix Spike Duplicate				Run: ICP1-HE_070529A				05/29/07 13:15
Sodium	127	mg/kg	1.0	80	80	120	0.0	20	
Sodium, Extractable	5.52	meq/100g	0.044	81	80	120	0.0	20	
Sample ID: MB-3342	Method Blank				Run: ICP1-HE_070529A				05/29/07 10:24
Sodium	5	mg/kg	0.02						
Sodium, Extractable	0.2	meq/100g	0.0009						
Sample ID: LCS-3342	Laboratory Control Sample				Run: ICP1-HE_070529A				05/29/07 10:27
Sodium	63.8	mg/kg	1.0	91	80	120			
Sodium, Extractable	2.78	meq/100g	0.044	91	80	120			

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Flying T

Report Date: 06/03/07
Work Order: H07050254

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B									Analytical Run: ICP1-HE_070529A
Sample ID: CCV	Continuing Calibration Verification Standard								05/29/07 13:28
Sodium	236	mg/kg	1.0	94	90	110			
Sodium, Extractable	10.2	meq/100g	0.044	94	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/29/07 13:31
Sodium	0.0732	mg/kg	1.0						
Sodium, Extractable	0.00318	meq/100g	0.044						
Sample ID: CCV	Continuing Calibration Verification Standard								05/29/07 14:01
Sodium	238	mg/kg	1.0	95	90	110			
Sodium, Extractable	10.3	meq/100g	0.044	95	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/29/07 14:03
Sodium	0.0732	mg/kg	1.0						
Sodium, Extractable	0.00318	meq/100g	0.044						
Sample ID: CCV	Continuing Calibration Verification Standard								05/29/07 14:22
Sodium	240	mg/kg	1.0	96	90	110			
Sodium, Extractable	10.4	meq/100g	0.044	96	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/29/07 14:25
Sodium	0.0732	mg/kg	1.0						
Sodium, Extractable	0.00318	meq/100g	0.044						
Sample ID: ICV	Initial Calibration Verification Standard								05/29/07 08:50
Sodium	44.7	mg/L	1.0	90	90	110			
Sample ID: ICV	Initial Calibration Verification Standard								05/29/07 10:11
Sodium	52.5	mg/kg	1.0	105	90	110			
Sodium, Extractable	2.28	meq/100g	0.044	105	90	110			
Sample ID: CCV	Continuing Calibration Verification Standard								05/29/07 10:19
Sodium	248	mg/kg	1.0	99	90	110			
Sodium, Extractable	10.8	meq/100g	0.044	99	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/29/07 10:22
Sodium	0.0732	mg/kg	1.0						
Sodium, Extractable	0.00318	meq/100g	0.044						
Sample ID: CCV	Continuing Calibration Verification Standard								05/29/07 10:51
Sodium	245	mg/kg	1.0	98	90	110			
Sodium, Extractable	10.7	meq/100g	0.044	98	90	110			

Qualifiers:

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ND - Not detected at the reporting limit.

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Flying T

Report Date: 06/03/07
Work Order: H07050254

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B									Analytical Run: ICP1-HE_070529A
Sample ID: CCB	Continuing Calibration Blank								05/29/07 10:54
Sodium	0.0732	mg/kg	1.0						
Sodium, Extractable	0.00318	meq/100g	0.044						
Sample ID: CCV	Continuing Calibration Verification Standard								05/29/07 11:20
Sodium	230	mg/kg	1.0	92	90	110			
Sodium, Extractable	10.0	meq/100g	0.044	92	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/29/07 11:23
Sodium	0.0732	mg/kg	1.0						
Sodium, Extractable	0.00318	meq/100g	0.044						
Sample ID: CCV	Continuing Calibration Verification Standard								05/29/07 11:52
Sodium	236	mg/kg	1.0	95	90	110			
Sodium, Extractable	10.3	meq/100g	0.044	95	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/29/07 11:55
Sodium	0.0732	mg/kg	1.0						
Sodium, Extractable	0.00318	meq/100g	0.044						
Sample ID: CCV	Continuing Calibration Verification Standard								05/29/07 12:24
Sodium	229	mg/kg	1.0	92	90	110			
Sodium, Extractable	9.95	meq/100g	0.044	92	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/29/07 12:27
Sodium	0.0732	mg/kg	1.0						
Sodium, Extractable	0.00318	meq/100g	0.044						
Sample ID: CCV	Continuing Calibration Verification Standard								05/29/07 12:56
Sodium	232	mg/kg	1.0	93	90	110			
Sodium, Extractable	10.1	meq/100g	0.044	93	90	110			
Method: SW6010B									Analytical Run: ICP1-HE_070601A
Sample ID: ICV	Initial Calibration Verification Standard								06/01/07 07:58
Calcium	47.2	mg/L	1.0	94	90	110			
Calcium, sat. paste	2.36	meq/L	0.050	94	90	110			
Method: USDA23c									Batch: 3343
Sample ID: LCS0705300000	Laboratory Control Sample				Run: MISC SOILS_070531D				05/30/07 00:00
Lime as CaCO3	5.92	%	0.10	97	70	130			

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Flying T

Report Date: 06/03/07
Work Order: H07050254

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: USDA27a									Batch: 3340
Sample ID: H07050248-010ADUP	Sample Duplicate				Run: MISC SOILS_070601H				05/29/07 14:19
Saturation	53.6	%	0.10				0.3	30	
Sample ID: LCS	Laboratory Control Sample				Run: MISC SOILS_070601H				05/29/07 14:19
Saturation	48.7	%	0.10	93	80	120			

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Date: *04-Jun-07*

CLIENT: Williams Production RMT
Project: Beaver Creek Sec 20 Little Buffalo
Sample Delivery Group: H07050249

CASE NARRATIVE

Sample Little Buffalo 0-6-001 was submitted to DCM Science Laboratory in Wheat Ridge, CO for Clay Mineralogy. Attached is the Report.

DCM Science Laboratory, Inc.
12421 W. 49th Avenue, Unit #6
Wheat Ridge, CO 80033 - (303) 463-8270

Quantitative Clay Analysis (XRD)

Client:
Energy Laboratories, Inc.
3161 E. Lyndale
Helena, MT 59601

Analysis Date:	5-25-07
Reporting Date:	5-31-07
Receipt Date:	5-25-07
Client Job No.:	H07050249
Project Title:	None Given
DCMSL Project:	ELAB18

Client Sample No.:	**H07050249 001**
Clay Fraction <2μm	
Smectite	42
Illite	37
Kaolinite	21

An oriented clay mount (<2μm) was prepared for x-ray diffraction and scanned over a range of 3° to 45° 2Θ using CuKα radiation, 40kV, 25mA. The mount was analyzed air dried (RH ~25%) and glycolated. Clay concentrations are based on peak areas and intensity factors measured in-house on known standards or computer calculated.

Ron Schott

Ron Schott, Analyst

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LABORATORY ANALYTICAL REPORT

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Little Buffalo
Workorder: H07050249

Report Date: 06/03/07
Date Received: 05/22/07

		Analysis		pH-SatPst	COND	Percent Sat	SAR	Ca-SatPst	Mg-SatPst	Na-SatPst	K-SatPst	SO4-SatPst	Sand	Silt
		Units		s_u_	mmhos/cm	%	unitless	meq/l	meq/l	meq/l	meq/l	meq/L	%	%
Sample ID	**Client Sample ID**	**Up**	**Low**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
H07050249-001	Little Buffalo 0-6"	0	0	7.2	3.69	61.9	3.9	20.2	6.86	14.4	1.68	38.0	42	36
H07050249-002	Little Buffalo 6-12"	0	0	7.7	5.62	56.6	11	19.7	9.84	40.9	0.77	72.4	26	49
H07050249-003	Little Buffalo 12-24"	0	0	8.1	12.1	55.8	22	18.8	29.8	109	0.45	164	32	45
H07050249-004	Little Buffalo 24-36"	0	0	8.0	12.5	52.7	18	20.7	36.5	96.4	0.41	164	33	42
H07050249-005	Little Buffalo 36-48"	0	0	7.9	8.41	48.8	13	19.6	31.6	66.1	0.39	126	35	40
H07050249-006	Little Buffalo 48-72	0	0	7.8	7.69	45.0	12	22.0	24.2	58.9	0.37	114	46	35

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LABORATORY ANALYTICAL REPORT

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Little Buffalo
Workorder: H07050249

Report Date: 06/03/07
Date Received: 05/22/07

		Analysis		Clay	Texture	OM-WB	CEC	Lime	Na-Ext	Exch Na	ESP
		Units		%	unitless	%	meq/100g	%	meq/100g	meq/100g	%
Sample ID	**Client Sample ID**	**Up**	**Low**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
H07050249-001	Little Buffalo 0-6"	0	0	22	L	4.62	30.0	2.9	2.24	1.4	4.5
H07050249-002	Little Buffalo 6-12"	0	0	25	L	2.46	25.3	3.7	4.96	2.6	10
H07050249-003	Little Buffalo 12-24"	0	0	23	L	1.62	23.3	3.4	12.9	6.9	29
H07050249-004	Little Buffalo 24-36"	0	0	25	L	1.35	21.3	3.1	9.70	4.6	22
H07050249-005	Little Buffalo 36-48"	0	0	25	L	1.38	20.2	3.6	6.68	3.4	17
H07050249-006	Little Buffalo 48-72	0	0	19	L	1.04	18.8	3.6	5.05	2.4	13

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Little Buffalo

Report Date: 06/03/07
Work Order: H07050249

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASA29-3									Batch: 3345
Sample ID: H07050248-010ADUP	Sample Duplicate				Run: MISC SOILS_070529B				05/29/07 12:06
Organic Matter	2.56	%	0.020				1.3	30	
Sample ID: LCS0705291206	Laboratory Control Sample				Run: MISC SOILS_070529B				05/29/07 12:06
Organic Matter	2.02	%	0.020	102	70	130			
Sample ID: MBLK0705291206	Method Blank				Run: MISC SOILS_070529B				05/29/07 12:06
Organic Matter	0.07	%	0.009						
Method: ASAM10-3									Batch: 3340
Sample ID: H07050248-010ADUP	Sample Duplicate				Run: MISC SOILS_070601H				05/29/07 14:19
Conductivity, sat. paste	0.500	mmhos/cm	0.010				18	30	
Sample ID: LCS	Laboratory Control Sample				Run: MISC SOILS_070601I				05/29/07 14:19
Conductivity, sat. paste	5.57	mmhos/cm	0.010	118	70	130			
Method: ASAM10-3.2									Batch: 3340
Sample ID: H07050248-010ADUP	Sample Duplicate				Run: MISC SOILS_070601H				05/29/07 14:19
pH, sat. paste	7.30	s.u.	0.10				0.0	30	
Sample ID: LCS	Laboratory Control Sample				Run: MISC SOILS_070601I				05/29/07 14:19
pH, sat. paste	7.20	s.u.	0.10	97	80	120			
Method: Calculation									Batch: R37690
Sample ID: LCS	Laboratory Control Sample				Run: MISC SOILS_070601I				05/29/07 14:19
Sodium Adsorption Ratio (SAR)	6.8	unitless	0.010	96	80	120			

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Little Buffalo

Report Date: 06/03/07
Work Order: H07050249

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B								Analytical Run: ICP1-HE_070601A	
Sample ID: ICV	Initial Calibration Verification Standard								06/01/07 08:22
Calcium	51.1	mg/L	1.0	102	90	110			
Magnesium	49.0	mg/L	1.0	98	90	110			
Sodium	51.3	mg/L	1.0	103	90	110			
Calcium, sat. paste	2.55	meq/L	0.050	102	90	110			
Magnesium, sat. paste	4.03	meq/L	0.082	98	90	110			
Sodium, sat. paste	2.23	meq/L	0.044	103	90	110			
Sample ID: CCV	Continuing Calibration Verification Standard								06/01/07 08:30
Sulfate	791	mg/L	1.0	106	90	110			
Calcium	266	mg/L	1.0	106	90	110			
Magnesium	259	mg/L	1.0	104	90	110			
Potassium	48.6	mg/L	1.0	97	90	110			
Sodium	255	mg/L	1.0	102	90	110			
Calcium, sat. paste	13.3	meq/L	0.050	106	90	110			
Magnesium, sat. paste	21.3	meq/L	0.082	104	90	110			
Sodium, sat. paste	11.1	meq/L	0.044	102	90	110			
Potassium, sat. paste	1.24	meq/L	0.026	97	90	110			
Sulfate, sat. paste	16.5	meq/L	0.021	106	90	110			
Sample ID: CCB	Continuing Calibration Blank								06/01/07 08:32
Sulfate	0.0909	mg/L	1.0						
Calcium	0.00890	mg/L	1.0						
Magnesium	0.00740	mg/L	1.0						
Potassium	0.267	mg/L	1.0						
Sodium	0.358	mg/L	1.0						
Calcium, sat. paste	0.000444	meq/L	0.050						
Magnesium, sat. paste	0.000609	meq/L	0.082						
Sodium, sat. paste	0.0156	meq/L	0.044						
Potassium, sat. paste	0.00684	meq/L	0.026						
Sulfate, sat. paste	0.00189	meq/L	0.021						
Sample ID: CCV	Continuing Calibration Verification Standard								06/01/07 09:02
Calcium	267	mg/L	1.0	107	90	110			
Magnesium	255	mg/L	1.0	102	90	110			
Potassium	47.0	mg/L	1.0	94	90	110			
Sodium	252	mg/L	1.0	101	90	110			
Calcium, sat. paste	13.3	meq/L	0.050	107	90	110			
Magnesium, sat. paste	21.0	meq/L	0.082	102	90	110			
Sodium, sat. paste	11.0	meq/L	0.044	101	90	110			
Potassium, sat. paste	1.20	meq/L	0.026	94	90	110			

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Little Buffalo

Report Date: 06/03/07
Work Order: H07050249

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B									Analytical Run: ICP1-HE_070601A
Sample ID: CCB	Continuing Calibration Blank								06/01/07 09:04
Sulfate	0.0909	mg/L	1.0						
Calcium	0.00890	mg/L	1.0						
Magnesium	0.00740	mg/L	1.0						
Potassium	0.255	mg/L	1.0						
Sodium	0.264	mg/L	1.0						
Calcium, sat. paste	0.000444	meq/L	0.050						
Magnesium, sat. paste	0.000609	meq/L	0.082						
Sodium, sat. paste	0.0115	meq/L	0.044						
Potassium, sat. paste	0.00653	meq/L	0.026						
Sulfate, sat. paste	0.00189	meq/L	0.021						
Sample ID: CCV	Continuing Calibration Verification Standard								06/01/07 09:34
Calcium	258	mg/L	1.0	103	90	110			
Magnesium	261	mg/L	1.0	104	90	110			
Potassium	47.6	mg/L	1.0	95	90	110			
Sodium	254	mg/L	1.0	102	90	110			
Calcium, sat. paste	12.9	meq/L	0.050	103	90	110			
Magnesium, sat. paste	21.4	meq/L	0.082	104	90	110			
Sodium, sat. paste	11.1	meq/L	0.044	102	90	110			
Potassium, sat. paste	1.22	meq/L	0.026	95	90	110			
Sample ID: CCB	Continuing Calibration Blank								06/01/07 09:36
Sulfate	0.0909	mg/L	1.0						
Calcium	0.00890	mg/L	1.0						
Magnesium	0.00740	mg/L	1.0						
Potassium	0.270	mg/L	1.0						
Sodium	0.311	mg/L	1.0						
Calcium, sat. paste	0.000444	meq/L	0.050						
Magnesium, sat. paste	0.000609	meq/L	0.082						
Sodium, sat. paste	0.0135	meq/L	0.044						
Potassium, sat. paste	0.00691	meq/L	0.026						
Sulfate, sat. paste	0.00189	meq/L	0.021						
Sample ID: CCV	Continuing Calibration Verification Standard								06/01/07 10:06
Calcium	247	mg/L	1.0	99	90	110			
Magnesium	254	mg/L	1.0	102	90	110			
Potassium	47.2	mg/L	1.0	94	90	110			
Sodium	243	mg/L	1.0	97	90	110			
Calcium, sat. paste	12.3	meq/L	0.050	99	90	110			
Magnesium, sat. paste	20.9	meq/L	0.082	102	90	110			
Sodium, sat. paste	10.6	meq/L	0.044	97	90	110			

Qualifiers:

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Little Buffalo

Report Date: 06/03/07
Work Order: H07050249

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B								Analytical Run: ICP1-HE_070601A	
Sample ID: CCV	Continuing Calibration Verification Standard								06/01/07 10:06
Potassium, sat. paste	1.21	meq/L	0.026	94	90	110			
Sample ID: CCB	Continuing Calibration Blank								06/01/07 10:08
Sulfate	0.0909	mg/L	1.0						
Calcium	0.00890	mg/L	1.0						
Magnesium	0.00740	mg/L	1.0						
Potassium	0.255	mg/L	1.0						
Sodium	0.332	mg/L	1.0						
Calcium, sat. paste	0.000444	meq/L	0.050						
Magnesium, sat. paste	0.000609	meq/L	0.082						
Sodium, sat. paste	0.0144	meq/L	0.044						
Potassium, sat. paste	0.00651	meq/L	0.026						
Sulfate, sat. paste	0.00189	meq/L	0.021						
Sample ID: CCV	Continuing Calibration Verification Standard								06/01/07 10:43
Calcium	247	mg/L	1.0	99	90	110			
Magnesium	248	mg/L	1.0	99	90	110			
Potassium	46.6	mg/L	1.0	93	90	110			
Sodium	240	mg/L	1.0	96	90	110			
Calcium, sat. paste	12.3	meq/L	0.050	99	90	110			
Magnesium, sat. paste	20.4	meq/L	0.082	99	90	110			
Sodium, sat. paste	10.4	meq/L	0.044	96	90	110			
Potassium, sat. paste	1.19	meq/L	0.026	93	90	110			
Sample ID: CCB	Continuing Calibration Blank								06/01/07 10:46
Sulfate	0.0909	mg/L	1.0						
Calcium	0.00890	mg/L	1.0						
Magnesium	0.00740	mg/L	1.0						
Potassium	0.251	mg/L	1.0						
Sodium	0.396	mg/L	1.0						
Calcium, sat. paste	0.000444	meq/L	0.050						
Magnesium, sat. paste	0.000609	meq/L	0.082						
Sodium, sat. paste	0.0172	meq/L	0.044						
Potassium, sat. paste	0.00643	meq/L	0.026						
Sulfate, sat. paste	0.00189	meq/L	0.021						
Method: SW6010B									Batch: 3340
Sample ID: LCS-3340	Laboratory Control Sample				Run: ICP1-HE_070601A				06/01/07 08:35
Calcium	560	mg/L	1.0	114	80	120			
Magnesium	154	mg/L	1.0	103	80	120			
Potassium	29.1	mg/L	1.0	93	80	120			

Qualifiers:

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Little Buffalo

Report Date: 06/03/07
Work Order: H07050249

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B									Batch: 3340
Sample ID: LCS-3340	Laboratory Control Sample				Run: ICP1-HE_070601A				06/01/07 08:35
Sodium	703	mg/L	1.0	101	80	120			
Calcium, sat. paste	27.9	meq/L	0.050	114	80	120			
Magnesium, sat. paste	12.7	meq/L	0.082	105	80	120			
Sodium, sat. paste	30.6	meq/L	0.044	101	80	120			
Potassium, sat. paste	0.744	meq/L	0.026	94	80	120			
Sample ID: H07050248-010ADup	Sample Duplicate				Run: ICP1-HE_070601A				06/01/07 09:10
Calcium	80.8	mg/L	1.0				1.3	30	
Magnesium	12.9	mg/L	1.0				9.9	30	
Potassium	11.6	mg/L	1.0				3.4	30	
Sodium	19.8	mg/L	1.0				8.8	30	
Calcium, sat. paste	4.03	meq/L	0.050				1.3	30	
Magnesium, sat. paste	1.06	meq/L	0.082				9.9	30	
Sodium, sat. paste	0.863	meq/L	0.044				8.8	30	
Potassium, sat. paste	0.297	meq/L	0.026				3.4	30	
Sample ID: H07050249-004ADup	Sample Duplicate				Run: ICP1-HE_070601A				06/01/07 09:47
Sulfate	8070	mg/L	1.0				2.6	30	
Calcium	456	mg/L	1.0				9.6	30	
Magnesium	452	mg/L	1.0				1.8	30	
Potassium	17.2	mg/L	1.0				6.5	30	
Sodium	2300	mg/L	1.0				3.6	30	
Calcium, sat. paste	22.7	meq/L	0.050				9.6	30	
Magnesium, sat. paste	37.2	meq/L	0.082				1.8	30	
Sodium, sat. paste	99.9	meq/L	0.044				3.6	30	
Potassium, sat. paste	0.440	meq/L	0.026				6.5	30	
Sulfate, sat. paste	168	meq/L	0.021				2.6	30	

Qualifiers:

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Little Buffalo

Report Date: 06/03/07
Work Order: H07050249

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B								Analytical Run: ICP1-HE_070531A	
Sample ID: ICV	Initial Calibration Verification Standard								05/31/07 08:55
Sodium	51.3	mg/kg	1.0	103	90	110			
Cation Exchange Capacity	4.46	meq/100g	0.087	103	90	110			
Sample ID: CCV	Continuing Calibration Verification Standard								05/31/07 09:03
Sodium	249	mg/kg	1.0	99	90	110			
Cation Exchange Capacity	21.6	meq/100g	0.087	103	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/31/07 09:05
Sodium	0.160	mg/kg	1.0						
Cation Exchange Capacity	0.0139	meq/100g	0.087						
Sample ID: CCV	Continuing Calibration Verification Standard								05/31/07 09:35
Sodium	238	mg/kg	1.0	95	90	110			
Cation Exchange Capacity	20.7	meq/100g	0.087	99	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/31/07 09:37
Sodium	0.164	mg/kg	1.0						
Cation Exchange Capacity	0.0143	meq/100g	0.087						
Sample ID: CCV	Continuing Calibration Verification Standard								05/31/07 10:07
Sodium	231	mg/kg	1.0	92	90	110			
Cation Exchange Capacity	20.1	meq/100g	0.087	96	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/31/07 10:09
Sodium	0.300	mg/kg	1.0						
Cation Exchange Capacity	0.0261	meq/100g	0.087						
Sample ID: CCV	Continuing Calibration Verification Standard								05/31/07 10:39
Sodium	234	mg/kg	1.0	93	90	110			
Cation Exchange Capacity	20.3	meq/100g	0.087	97	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/31/07 10:41
Sodium	0.223	mg/kg	1.0						
Cation Exchange Capacity	0.0194	meq/100g	0.087						
Sample ID: CCV	Continuing Calibration Verification Standard								05/31/07 11:11
Sodium	235	mg/kg	1.0	94	90	110			
Cation Exchange Capacity	20.4	meq/100g	0.087	97	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/31/07 11:13
Sodium	0.252	mg/kg	1.0						
Cation Exchange Capacity	0.0219	meq/100g	0.087						

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Little Buffalo

Report Date: 06/03/07
Work Order: H07050249

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B									Batch: 3341
Sample ID: LCS-3341	Laboratory Control Sample				Run: ICP1-HE_070531A				05/31/07 09:08
Sodium	294	mg/kg	1.0	94	80	120			
Cation Exchange Capacity	25.5	meq/100g	0.087	94	80	120			
Sample ID: H07050248-015AMS	Sample Matrix Spike				Run: ICP1-HE_070531A				05/31/07 10:01
Sodium	344	mg/kg	1.0	97	70	130			
Cation Exchange Capacity	29.9	meq/100g	0.087	97	70	130			
Sample ID: H07050248-015AMSD	Sample Matrix Spike Duplicate				Run: ICP1-HE_070531A				05/31/07 10:04
Sodium	344	mg/kg	1.0	97	70	130	0.0	30	
Cation Exchange Capacity	29.9	meq/100g	0.087	97	70	130	0.0	30	
Sample ID: H07050249-005ADup	Sample Duplicate				Run: ICP1-HE_070531A				05/31/07 10:25
Sodium	257	mg/kg	1.0				10.0	30	
Cation Exchange Capacity	22.4	meq/100g	0.087				10.0	30	
Method: SW6010B									Batch: 3342
Sample ID: H07050248-015AMS	Sample Matrix Spike				Run: ICP1-HE_070529A				05/29/07 13:12
Sodium	127	mg/kg	1.0	80	80	120			
Sodium, Extractable	5.52	meq/100g	0.044	81	80	120			
Sample ID: H07050248-015AMSD	Sample Matrix Spike Duplicate				Run: ICP1-HE_070529A				05/29/07 13:15
Sodium	127	mg/kg	1.0	80	80	120	0.0	20	
Sodium, Extractable	5.52	meq/100g	0.044	81	80	120	0.0	20	
Sample ID: MB-3342	Method Blank				Run: ICP1-HE_070529A				05/29/07 10:24
Sodium	5	mg/kg	0.02						
Sodium, Extractable	0.2	meq/100g	0.0009						
Sample ID: LCS-3342	Laboratory Control Sample				Run: ICP1-HE_070529A				05/29/07 10:27
Sodium	63.8	mg/kg	1.0	91	80	120			
Sodium, Extractable	2.78	meq/100g	0.044	91	80	120			
Method: SW6010B									Analytical Run: ICP1-HE_070531A
Sample ID: CCV	Continuing Calibration Verification Standard								05/31/07 11:40
Sodium	235	mg/kg	1.0	94	90	110			
Cation Exchange Capacity	20.4	meq/100g	0.087	97	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/31/07 11:43
Sodium	0.244	mg/kg	1.0						
Cation Exchange Capacity	0.0212	meq/100g	0.087						

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Little Buffalo

Report Date: 06/03/07
Work Order: H07050249

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B								Analytical Run: ICP1-HE_070529A	
Sample ID: CCV	Continuing Calibration Verification Standard								05/29/07 13:28
Sodium	236	mg/kg	1.0	94	90	110			
Sodium, Extractable	10.2	meq/100g	0.044	94	90	110			
Sample ID: CCV	Continuing Calibration Verification Standard								05/29/07 14:01
Sodium	238	mg/kg	1.0	95	90	110			
Sodium, Extractable	10.3	meq/100g	0.044	95	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/29/07 14:03
Sodium	0.0732	mg/kg	1.0						
Sodium, Extractable	0.00318	meq/100g	0.044						
Sample ID: CCV	Continuing Calibration Verification Standard								05/29/07 14:22
Sodium	240	mg/kg	1.0	96	90	110			
Sodium, Extractable	10.4	meq/100g	0.044	96	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/29/07 14:25
Sodium	0.0732	mg/kg	1.0						
Sodium, Extractable	0.00318	meq/100g	0.044						
Sample ID: ICV	Initial Calibration Verification Standard								05/29/07 08:50
Sodium	44.7	mg/L	1.0	90	90	110			
Sample ID: ICV	Initial Calibration Verification Standard								05/29/07 10:11
Sodium	52.5	mg/kg	1.0	105	90	110			
Sodium, Extractable	2.28	meq/100g	0.044	105	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/29/07 10:14
Sodium	0.0732	mg/kg	1.0						
Sodium, Extractable	0.00318	meq/100g	0.044						
Sample ID: CCV	Continuing Calibration Verification Standard								05/29/07 10:19
Sodium	248	mg/kg	1.0	99	90	110			
Sodium, Extractable	10.8	meq/100g	0.044	99	90	110			
Sample ID: CCB	Continuing Calibration Blank								05/29/07 10:22
Sodium	0.0732	mg/kg	1.0						
Sodium, Extractable	0.00318	meq/100g	0.044						
Sample ID: CCV	Continuing Calibration Verification Standard								05/29/07 10:51
Sodium	245	mg/kg	1.0	98	90	110			
Sodium, Extractable	10.7	meq/100g	0.044	98	90	110			

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QA/QC Summary Report

Client: Williams Production RMT
Project: Beaver Creek Sec 20 Little Buffalo

Report Date: 06/03/07
Work Order: H07050249

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B								Analytical Run: ICP1-HE_070529A	
Sample ID: CCB	Continuing Calibration Blank							05/29/07 10:54	
Sodium	0.0732	mg/kg	1.0						
Sodium, Extractable	0.00318	meq/100g	0.044						
Sample ID: CCV	Continuing Calibration Verification Standard							05/29/07 11:20	
Sodium	230	mg/kg	1.0	92	90	110			
Sodium, Extractable	10.0	meq/100g	0.044	92	90	110			
Sample ID: CCB	Continuing Calibration Blank							05/29/07 11:23	
Sodium	0.0732	mg/kg	1.0						
Sodium, Extractable	0.00318	meq/100g	0.044						
Method: SW6010B								Analytical Run: ICP1-HE_070601A	
Sample ID: ICV	Initial Calibration Verification Standard							06/01/07 07:58	
Calcium	47.2	mg/L	1.0	94	90	110			
Calcium, sat. paste	2.36	meq/L	0.050	94	90	110			
Method: USDA23c								Batch: 3343	
Sample ID: LCS0705300000	Laboratory Control Sample				Run: MISC SOILS_070531F			05/30/07 00:00	
Lime as CaCO3	5.92	%	0.10	97	70	130			
Sample ID: H07050246-010ADUP	Sample Duplicate				Run: MISC SOILS_070601G			05/30/07 00:00	
Lime as CaCO3	1.43	%	0.10				7.3	30	
Sample ID: H07050246-020ADUP	Sample Duplicate				Run: MISC SOILS_070601G			05/30/07 00:00	
Lime as CaCO3	0.576	%	0.10				23	30	
Sample ID: H07050246-030ADUP	Sample Duplicate				Run: MISC SOILS_070601G			05/30/07 00:00	
Lime as CaCO3	3.94	%	0.10				0.7	30	

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