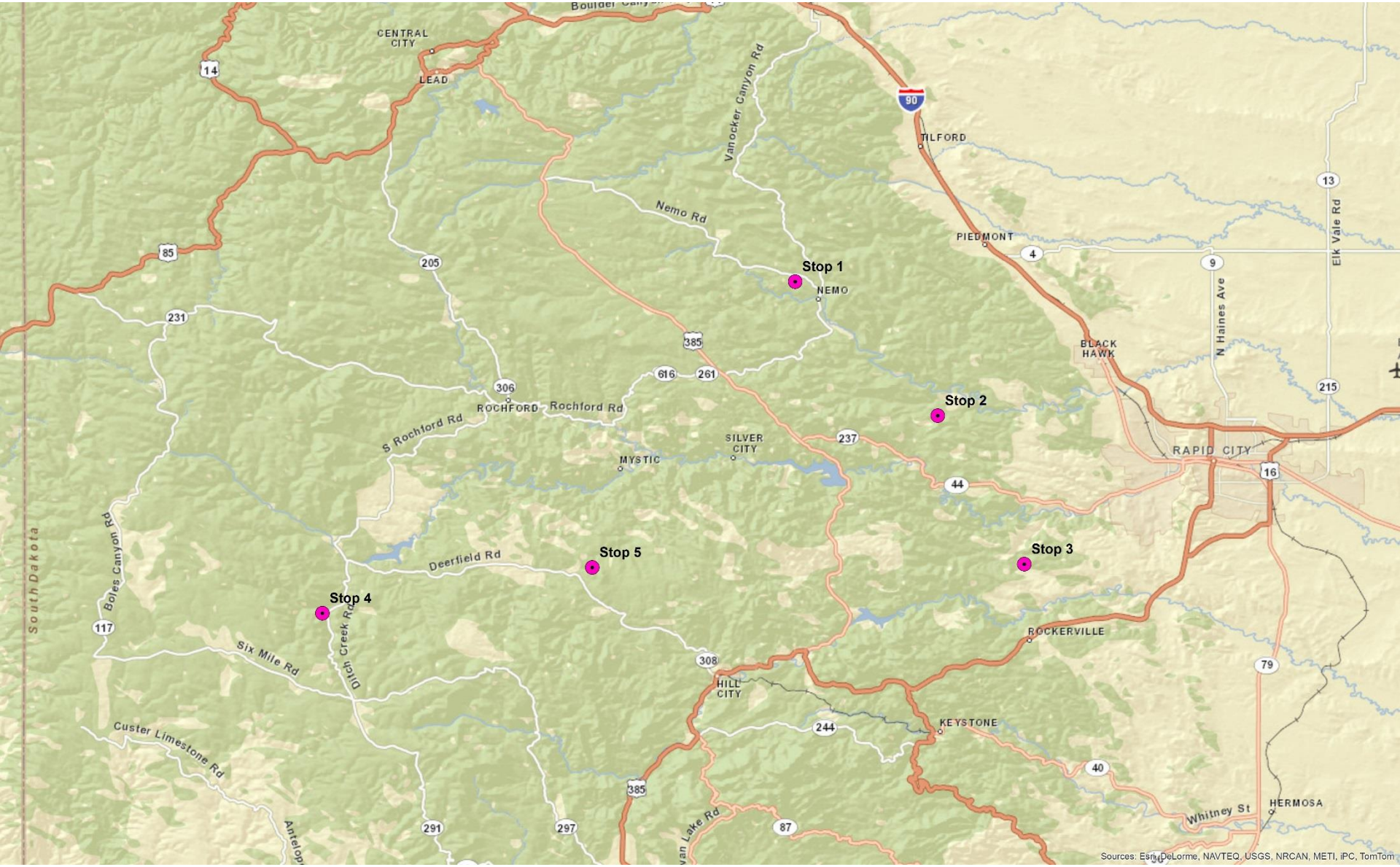
American Institute of Professional Geologists
South Dakota Section

2015 Field Trip Guide

Deadwood Formation in the Black Hills of South Dakota and "Frac Sand" Potential

Saturday, September 12, 2015

Field Trip Stops – September 12, 2015



Travel from DENR-Geological Survey Parking lot to Stop 1: 35 minutes

Stop 1 Outcrop of Lower Deadwood Formation and abandoned quarry on east east side of Old Sawmill Rd (FS678). Beds are thin- to thick-bedded. Grains are dominantly silica and have a bimodal distribution, with the larger grains being well-rounded compared to the smaller, sub-angular to sub-rounded grains. Some beds are quite friable due to weathering, but are cemented at depth. Depositional environments represented are tidal flat (thin-bedded) and higher energy nearshore (thick-bedded). A small quarry has some pieces with basal conglomerate, and has been excavated down to the Precambrian rocks [**see pages 4-12**]

Travel to Stop 2: 30 minutes

Stop 2 Outcrop of Upper Deadwood Formation along logging trail on east side of Norris Peak Road. Due to the shallow tidal flat (thin bedded) and nearshore to channel depositional environments (thick bedded), sedimentary features include cross-bedding with reactivation surfaces, ripple marks, and intraformational conglomerate. Limonitized *Scolithos* sp. burrows are also present [**see pages 13-21**]

Travel to Stop 3: 45 minutes

Stop 3 Exposure of paleochannel of basal Deadwood Formation along a tributary to Victoria Creek. The boulders in the channel are of Precambrian lithologies, clast supported, with some over 0.5 meter across. Clasts decrease in size away from the channel area, to cobbles, pebbles, and finally sand, reflecting varying water energy. Medium- to coarse-grained sand fills the pore space between the clasts [**see pages 22-24**]

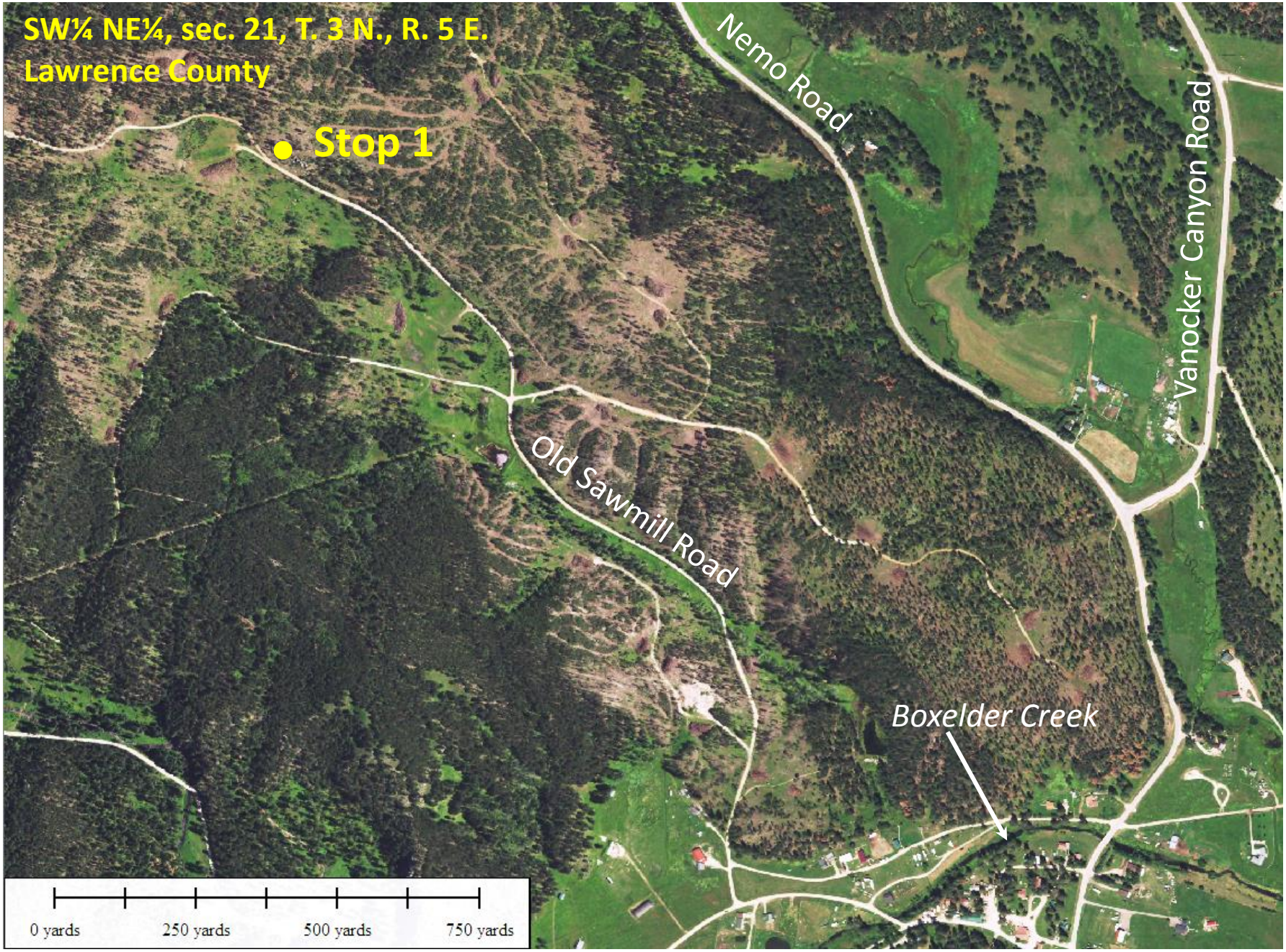
Travel to Stop 4: approx. 60 minutes

Stop 4 Abandoned frac-sand mine in the Lower Deadwood Formation just west of the intersection of Ditch Creek Road (FS291) and TR6021. The mine was worked by several intersecting adits that followed friable sandstone along weathered fractures. The remaining sandstone is very cemented. The exposures have a more uniform bedding thickness. Grains are dominantly silica and have a bimodal distribution, with the larger grains being well-rounded compared to the smaller, sub-angular to sub-rounded grains. Ripple marks are visible on the ceiling, with some having been disturbed by trilobite tracks and the trilobite feeding trace fossil *Rusophycus* sp. Depositional environments are beach to near shore facies (basal conglomerate and lower massive sandstones), grading upward into tidal flat facies (thin-bedded to laminated sandstone with interbedded shale) [**see pages 25-29**]

Travel to Stop 5: 30 minutes

Stop 5 Dr. Perry Rahn's (SDSM&T emeritus) "cabin" for refreshments. Take McVey Road to the north from Deerfield Road for about 0.5 mile. Turn right on FS331.1A and follow for about 1 mile to the end of the road [**see page 30**]

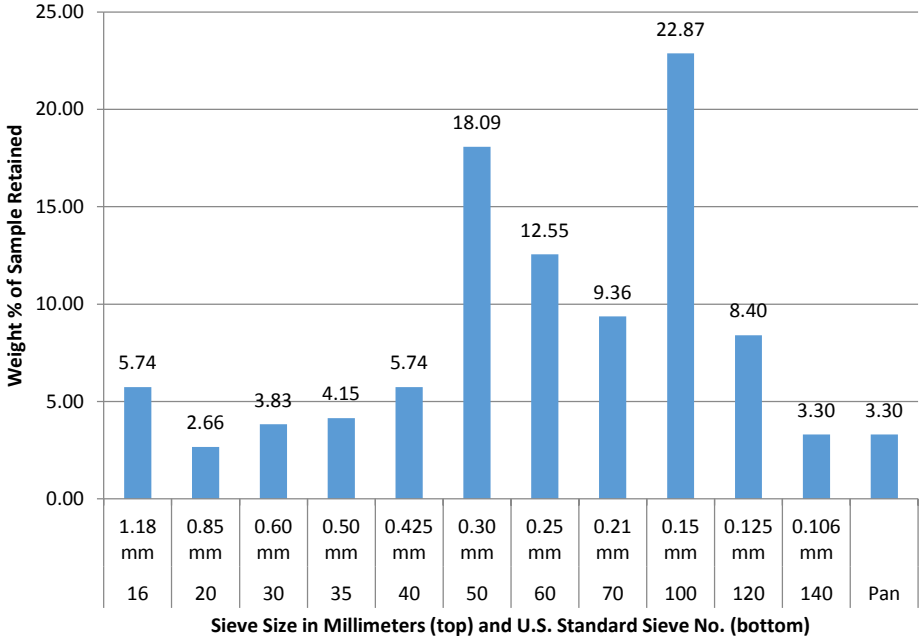
Return to Rapid City: 60 minutes

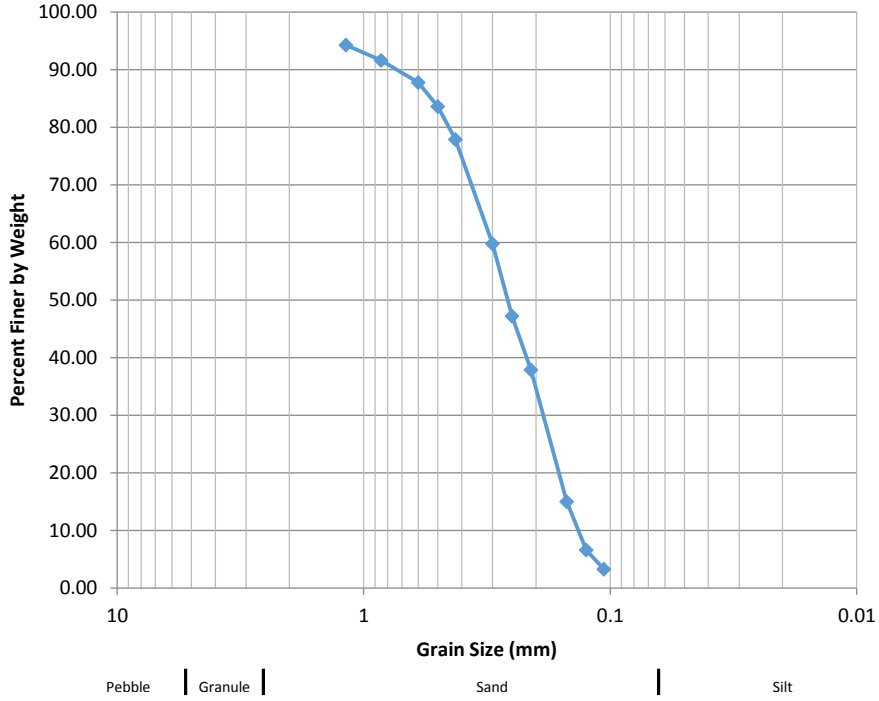

SW¼ NE¼, sec. 21, T. 3 N., R. 5 E.
Lawrence County
Stop 1
Nemo Road
Vanocker Canyon Road
Old Sawmill Road
Boxelder Creek
0 yards
250 yards
500 yards
750 yards

Deadwood Formation outcrop at Stop 1

"FracSand" study sample HFSC-2012-044 taken at this location

HFSC-2012-044 - Deadwood Formation





Estimated Percent Aggregates From Photomicrograph											
16	20	30	35	40	50	60	70	100	120	140	Pan
1.18 mm	0.85 mm	0.60 mm	0.50 mm	0.425 mm	0.30 mm	0.25 mm	0.21 mm	0.15 mm	0.125 mm	0.106 mm	
>70	>70	30-70	30-70	<30	<30	<30	<30	<30	<30	<30	<30

Sample ID: HFSC-2012-044
Geologic unit: Deadwood Formation
Sieve size: No. 16 (1.18 mm)
Magnification: 8x

Sample ID: HFSC-2012-044
Geologic unit: Deadwood Formation
Sieve size: No. 20 (0.85 mm)
Magnification: 8x

Sample ID: HFSC-2012-044
Geologic unit: Deadwood Formation
Sieve size: No. 30 (0.60 mm)
Magnification: 8x

Sample ID: HFSC-2012-044
Geologic unit: Deadwood Formation
Sieve size: No. 35 (0.50 mm)
Magnification: 8x

Sample ID: HFSC-2012-044
Geologic unit: Deadwood Formation
Sieve size: No. 40 (0.425 mm)
Magnification: 8x

Sample ID: HFSC-2012-044
Geologic unit: Deadwood Formation
Sieve size: No. 50 (0.300 mm)
Magnification: 30x

Sample ID: HFSC-2012-044
Geologic unit: Deadwood Formation
Sieve size: No. 60 (0.250 mm)
Magnification: 30x

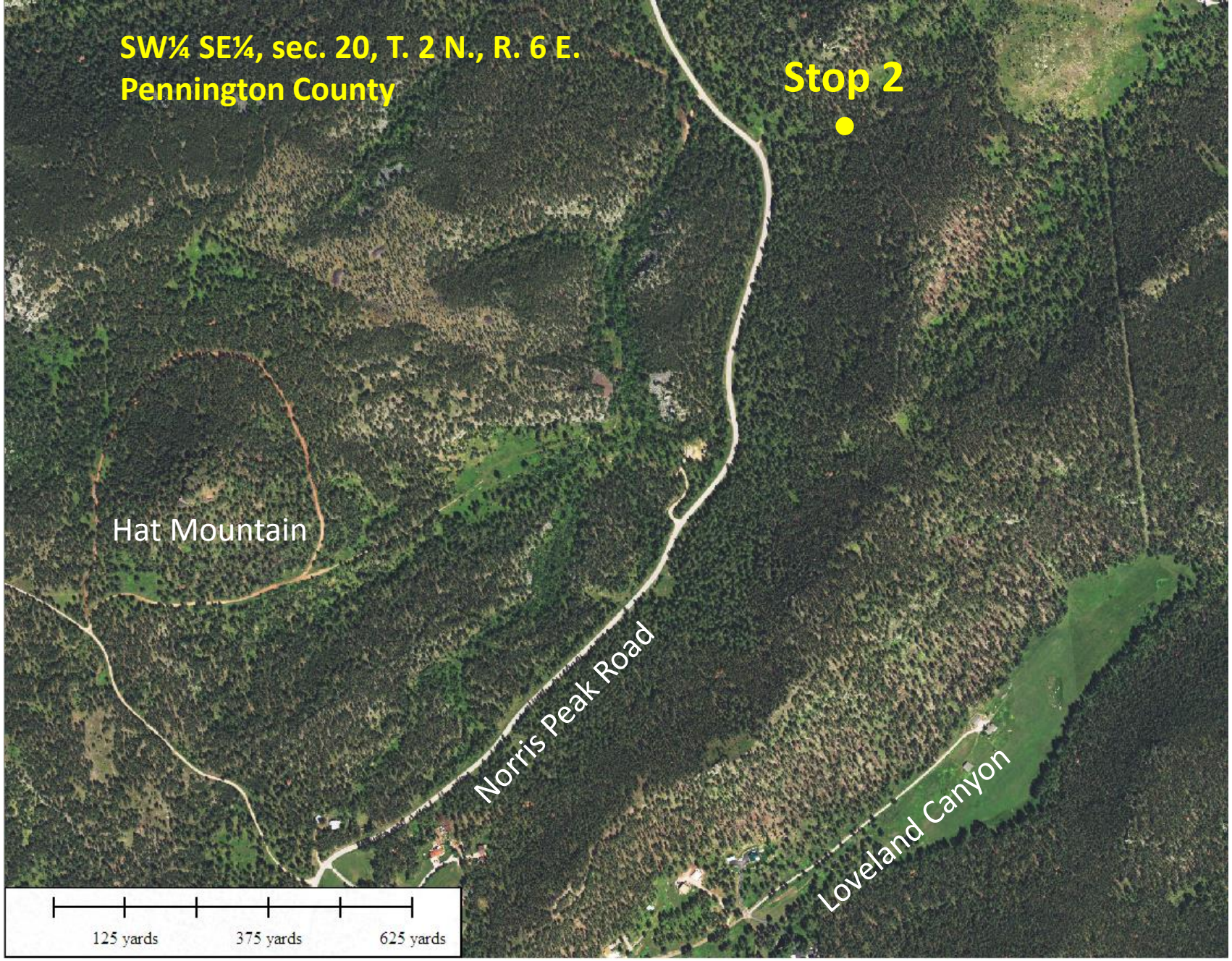
Sample ID: HFSC-2012-044
Geologic unit: Deadwood Formation
Sieve size: No. 70 (0.212 mm)
Magnification: 30x

Sample ID: HFSC-2012-044
Geologic unit: Deadwood Formation
Sieve size: No. 100 (0.150 mm)
Magnification: 30x

Sample ID: HFSC-2012-044
Geologic unit: Deadwood Formation
Sieve size: No. 120 (0.125 mm)
Magnification: 30x

Sample ID: HFSC-2012-044
Geologic unit: Deadwood Formation
Sieve size: No. 140 (0.106 mm)
Magnification: 30x

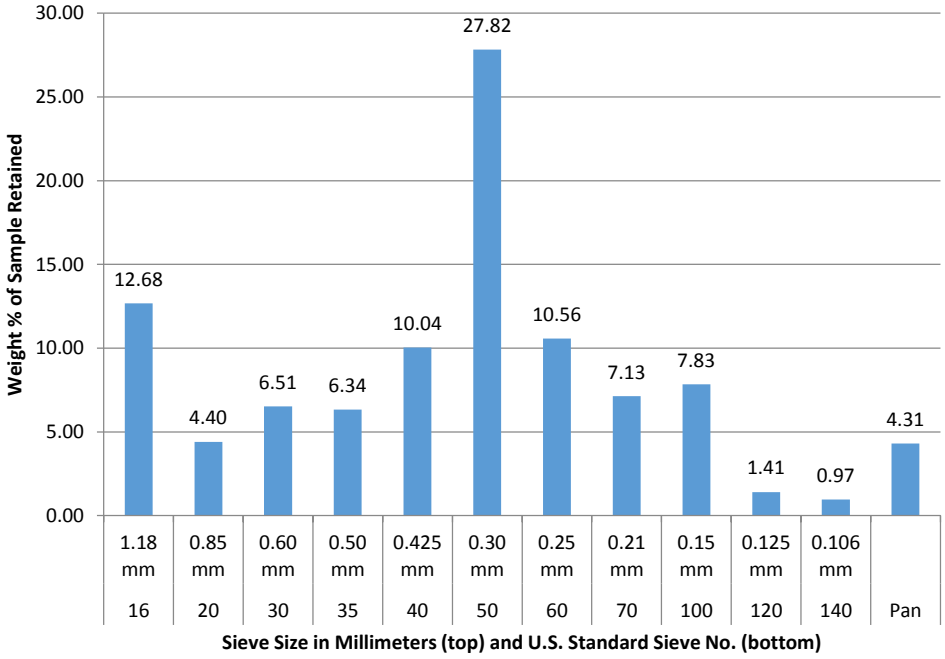
Sample ID: HFSC-2012-044
Geologic unit: Deadwood Formation
Sieve size: Pan
Magnification: 30x

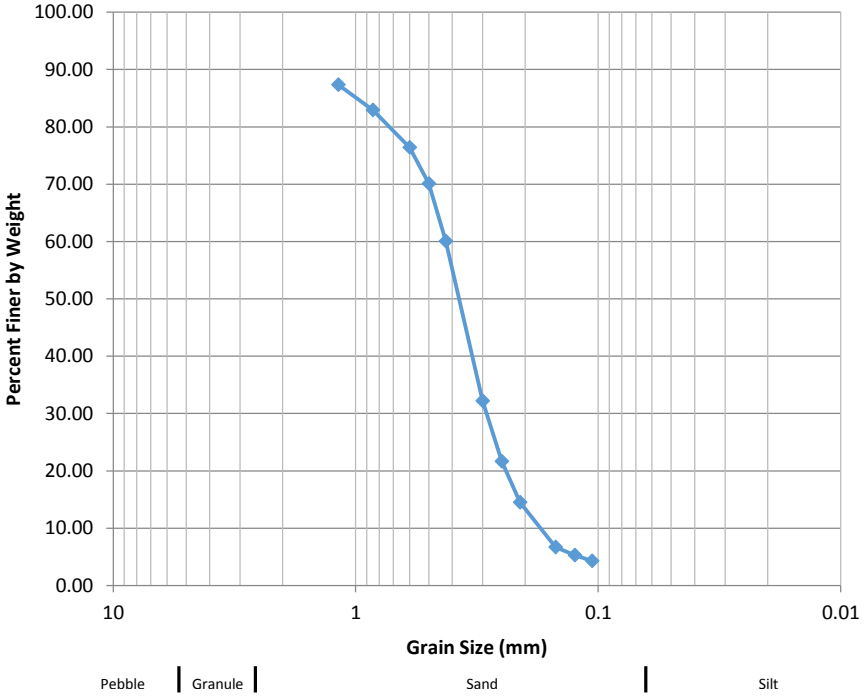

SW¼ SE¼, sec. 20, T. 2 N., R. 6 E.
Pennington County
Stop 2
Hat Mountain
Norris Peak Road
Loveland Canyon
125 yards
375 yards
625 yards

Deadwood Formation outcrop at Stop 2

"FracSand" study sample HFSC-2013-090 taken at this location

HFSC-2013-090 - Deadwood Formation





Estimated Percent Aggregates From Photomicrograph											
16	20	30	35	40	50	60	70	100	120	140	Pan
1.18 mm	0.85 mm	0.60 mm	0.50 mm	0.425 mm	0.30 mm	0.25 mm	0.21 mm	0.15 mm	0.125 mm	0.106 mm	
100	100	>70	30-70	<30	<30	<30	<30	<30	<30	<30	<30

Sample ID: HFSC-2013-090
Geologic unit: Deadwood Formation
Sieve size: No. 16 (1.18 mm)
Magnification: 8x

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Sieve size: No. 30 (0.60 mm)
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Geologic unit: Deadwood Formation
Sieve size: No. 35 (0.50 mm)
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Geologic unit: Deadwood Formation
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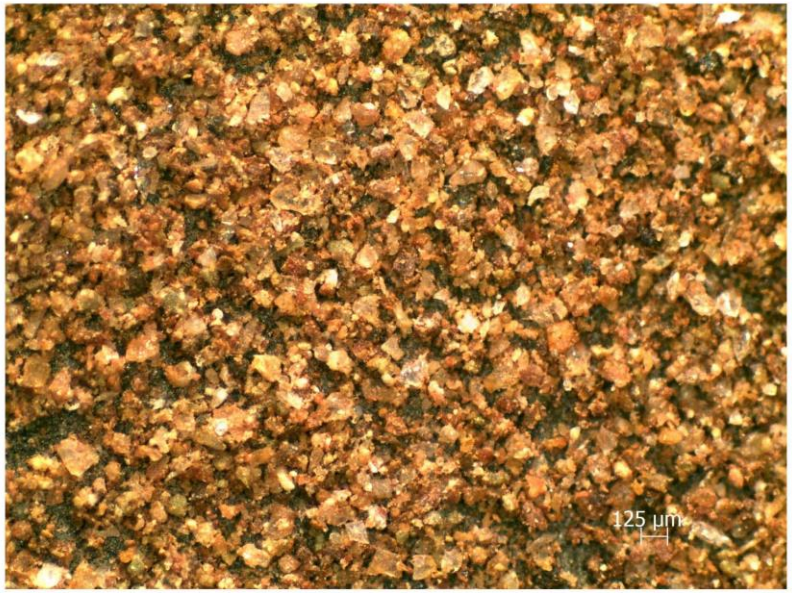
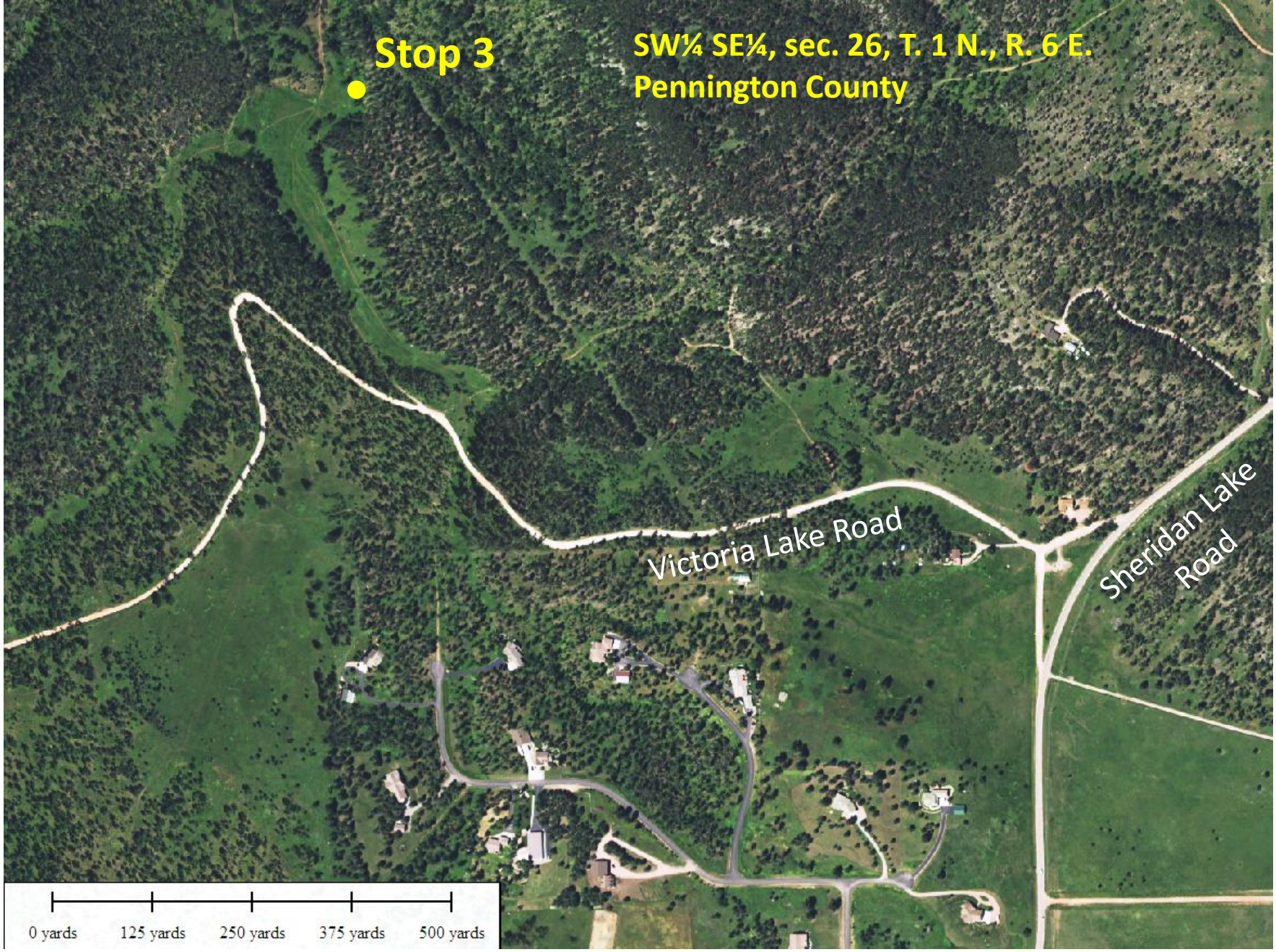
Magnification: 30x

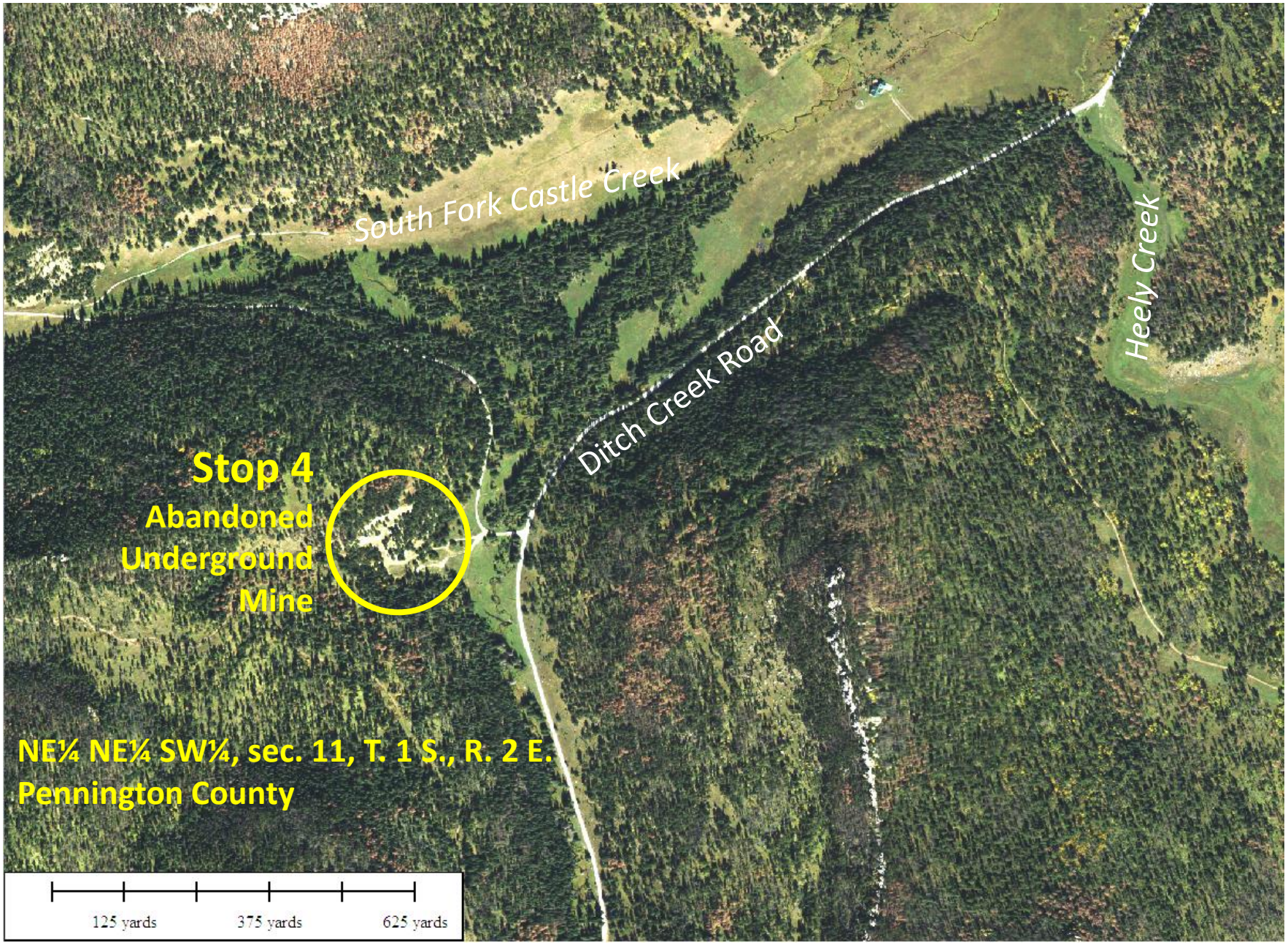
Sample ID: HFSC-2013-090
Geologic unit: Deadwood Formation
Sieve size: Pan
Magnification: 30x



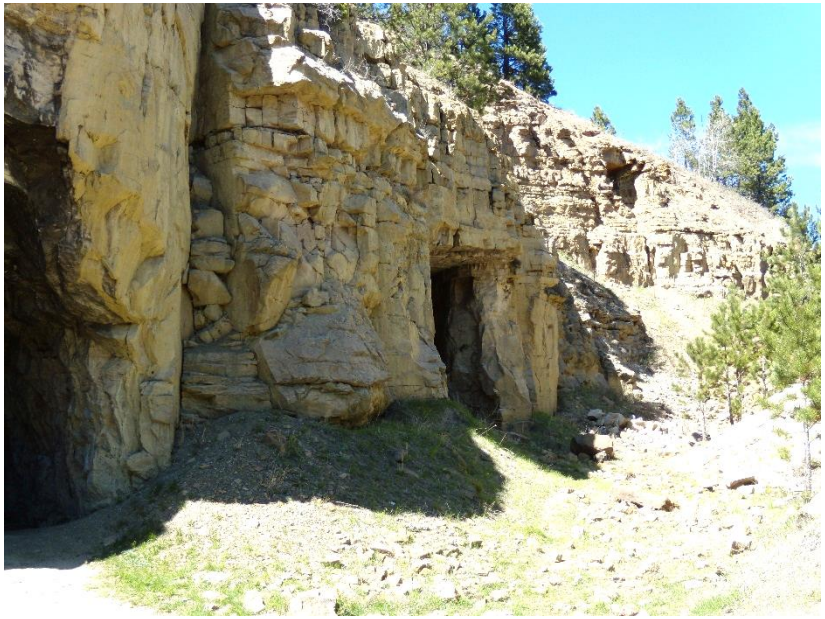

Stop 3
SW¼ SE¼, sec. 26, T. 1 N., R. 6 E.
Pennington County
Victoria Lake Road
Sheridan Lake Road
0 yards
125 yards
250 yards
375 yards
500 yards

Deadwood Formation outcrop at Stop 3

Deadwood Formation outcrop at Stop 3

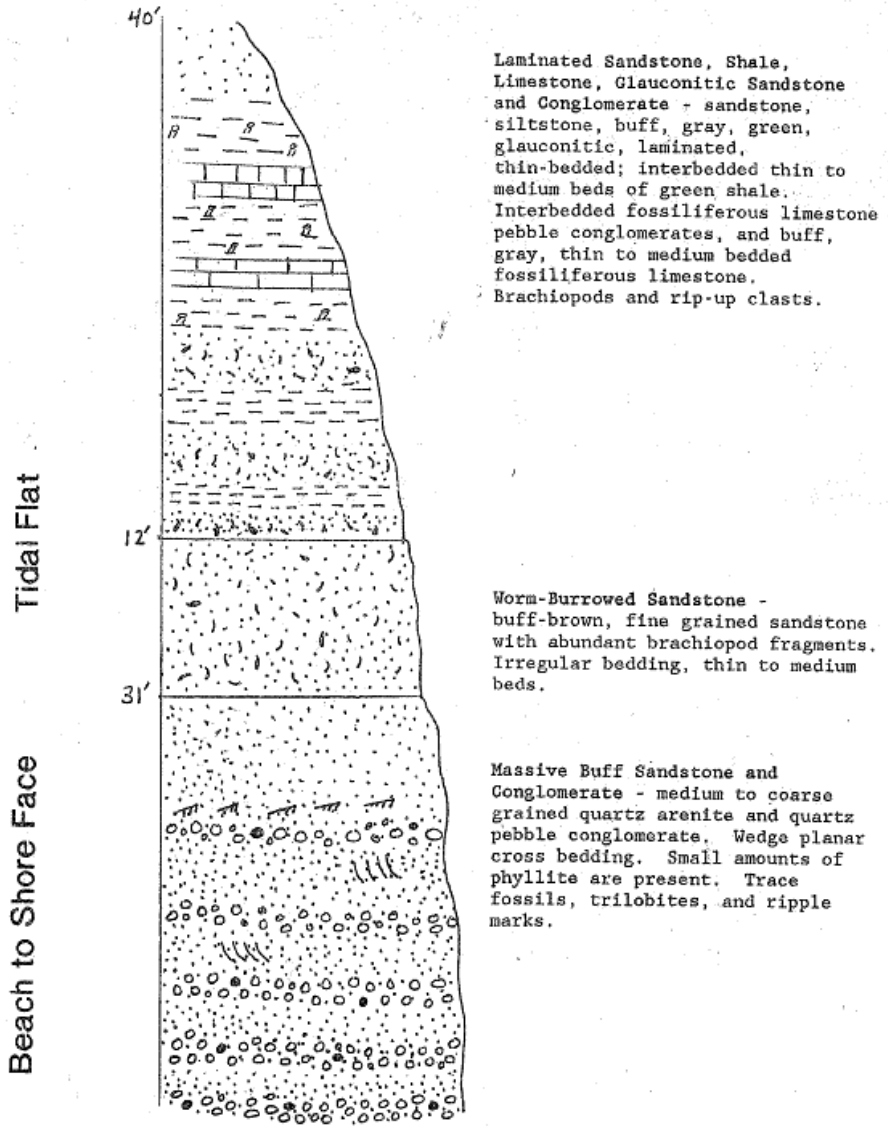

South Fork Castle Creek
Heely Creek
Ditch Creek Road
Stop 4
Abandoned
Underground
Mine
NE¼ NE¼ SW¼, sec. 11, T. 1 S., R. 2 E.
Pennington County
125 yards
375 yards
625 yards

Abandoned mine at Stop 4
Deadwood Formation outcrop



DEADWOOD FORMATION

UpperCambrian Deadwood Formation located at the Silica Sand Mine, Ditch Creek Quad, NE, NE, SW, sec. 11, T1S, R2E.



From – Kulik, J.W., 1965, Stratigraphy of the Deadwood Formation, Black Hills, South Dakota and Wyoming: Master's Thesis on file at South Dakota School of Mines and Technology.

Results of "measurement of properties for proppants used in hydraulic fracturing and gravel-packing operations" evaluations on 30/50 sand sample

Table 1

Sieve Analysis of Submitted Proppant Sample
Submitted By: Pat Meile
ISO 13503-2/API RP19C, Section 6, "Sieve Analysis"

Sample I.D.	Proppant Sample Labeled: Composite		
US Standard Sieve No.	Weight % Retained	Cumulative	
6	0.0	0.0	
8	0.0	0.0	
10	0.0	0.0	
12	0.1	0.1	
14	0.2	0.2	
16	0.2	0.5	
18	0.6	1.0	
20	1.2	2.2	
25	3.2	5.4	
30	8.1	13.5	
35	11.9	25.4	
40	14.3	39.7	
45	17.2	56.9	
50	14.3	71.2	
60	10.3	81.5	
70	7.1	88.6	
80	4.8	93.4	
100	3.0	96.5	
120	1.6	98.0	
140	1.1	99.1	
170	0.6	99.6	
200	0.2	99.9	
230	0.0	99.9	
pan	0.0	99.9	
total	99.9		
in-size	0.1	= as 6/12	
in-size	0.5	= as 8/16	
in-size	2.2	= as 12/20	
in-size	13.1	= as 16/30	
in-size	37.5	= as 20/40	
in-size	57.6	= as 30/50	
in-size	48.9	= as 40/70	
in-size	10.4	= as 70/140	
ISO Mean Dia. (mm)	0.411		
Median Dia. (mm)	0.370		

June 2011

SL 9405

Table 2

Proppant Sample Labeled: 30/50
Submitted By: Pat Meile
Arrived 6/30/2011

Measurement of Properties of Proppants
Used In Hydraulic Fracturing and Gravel-Packing Operations

ISO 13503-2, Section 7, "Proppant Sphericity and Roundness"

* mean of a 20 count

Sphericity =	0.7
Roundness =	0.7
Clusters =	None Observed in Field of Count

Recommended Sphericity and Roundness for proppants = 0.6 or greater (ISO/DIS 13503-2/Amd.1/API RP19C)
Recommended Sphericity and Roundness for high strength proppants = 0.7 or greater (ISO/DIS 13503-2/Amd.1/API RP19C)

ISO 13503-2, Section 8, "Acid Solubility"

* mean of 3 analysis

Acid Sol. Percent =	0.7	%

Recommended Maximum Acid Solubility for ceramic proppants and resin coated ceramic proppants = 7.0%
Recommended Maximum Acid Solubility for proppants 6/12 thru 30/50 = 2.0%
Tested as per ISO 13503-2/API RP19C, 100ml of 12:3 HCl:HF* with 5 grams of sand or proppant at 150°F for 30 minutes, *Other acids may be specified, depending on desired application

ISO 13503-2/API RP19C, Section 9, "Turbidity Test"

	8	FTU

Method 1: Turbidity, suggested maximum frac sand turbidity = equal or less than 250 FTU per API RP-56 and 58

ISO 13503-2/API RP 19C, Section 10,
"Procedures for Determining Proppant Bulk Density, Apparent Density"

Bulk Density =	1.46	g/cm^3
Bulk Density =	91.1	lb/ft^3
Specific Gravity = (Oil per ISO) or Apparent Density	2.64	g/cm^3

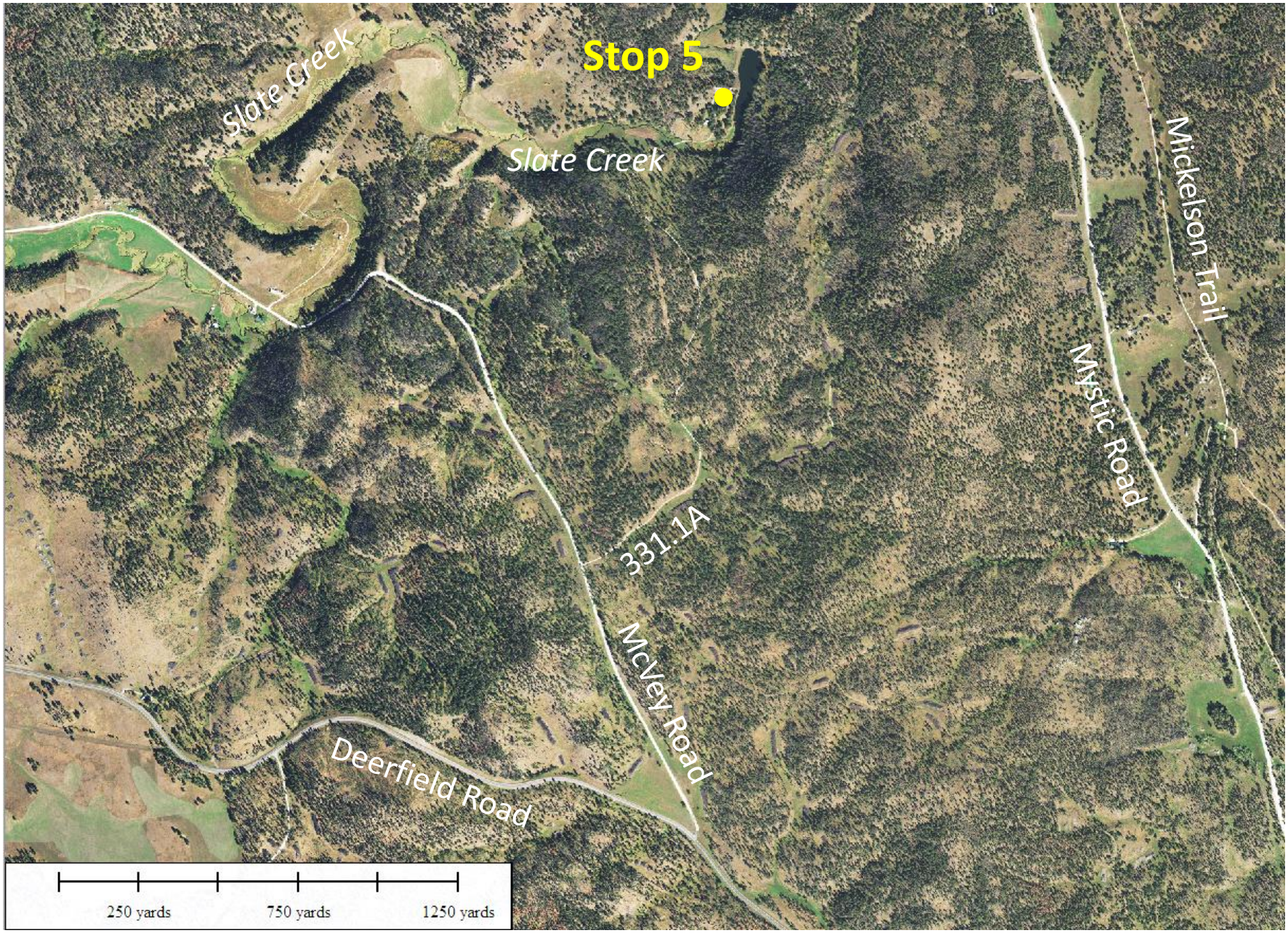
ISO 13503-2, Section 11, "Proppant Crush-Resistance Test"

Stresses Tested (psi)	% Fines -30+50 crush prep
4000	2.5
7000	9.6
8000	13.1
K-Value =	7K

Suggested maximum fines for 30/50 Frac Sand per API RP-56 = 10% @ 4000psi
The highest stress level which a proppant generates no more than 10% crushed material, rounded down to the nearest 1000psi = K-Value

June 2011

30/50


Stop 5
Slate Creek
Slate Creek
Mickelson Trail
Mystic Road
331.1A
McVey Road
Deerfield Road
250 yards
750 yards
1250 yards