APPENDIX B

Drill Cutting Log and Geologic Classification Test Well #2A

MORRISON-MAIERLE, INC.
DRILL CUTTING SAMPLE DESCRIPTIONS

TEST WELL #2A - GILLETTE MADISON PIPELINE PROJECT

Sample Depth Interval (feet BGL)	Lithology	Description
0 - 80	No samples	No samples.
Lakota Formation – Top not Identified – No Samples from Surface Conduit		
80 - 90	SANDSTONE	Med gray to maroon, vf qtz sand in white cement, very hard. (Lower Lakota Fm.)
90 - 100	SANDSTONE	Med gray, vf qtz sand in white cement and m-c, angular qtz sand, some with pyrite cement, trace of siltstone in sample. (Lower Lakota Fm.)
100 - 110	SANDSTONE	As Above. (Lower Lakota Fm.)
110 - 120	SANDSTONE	Gray, vc-gran, rounded quartzite granular sand and angular vc sand with dark access. Minerals (salt & pepper sand), trace iron pyrite cement. (Lower Lakota Fm.)
120 - 130	SANDSTONE	As above. (Lower Lakota Fm.)
Morrison Formation - Top 139 feet		
130 - 140	MUDSTONE	Dk gray, 5% hard dk gry bn sis & vfs. (Morrison Fm.)
140 - 150	SILTSTONE	Med gray, 5% hard and minor vf ss, qtzose. (Morrison Fm.)
150 - 160	CLAYSTONE	Dk gray, firm, sticky, slightly sandy, clay, minor hard, laminated, sis & black mudstone and/or sandy shale.
160 - 170	CLAYSTONE	As above. (Morrison Fm.)
170 - 180	CLAYSTONE	As above. (Morrison Fm.)
180 - 190	CLAYSTONE	Medium gray, interbedded with v. thin, soft, vf sandstone. Ss is rounded qtz w/10% lithics. (Morrison Fm.)
190 - 200	CLAYSTONE	As above. (Morrison Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
200 - 210	SANDSTONE & CLAY	Lt. gray, vf sandstone with white cmt and 5-8% chert grains and v soft lt. gray clay. (Morrison Fm.)
210 - 220	SANDSTONE & CLAY	As above. (Morrison Fm.)
220 - 230	SANDSTONE & CLAY	As above. (Morrison Fm.)
Redwater Shale Member of Sundance Formation - Top 234 feet		
230 - 240	CLAYSTONE	V. dk gray, sandy, v. soft, 1-2% interbedded vf sandstone, trace carbonaceous material, trace iron pyrite. (Redwater sh mbr Sundance Fm).
240 - 250	CLAYSTONE	Med. greenish gray, soft, w/20% dk gray mudstone, trace pytite. (Redwater sh mbr Sundance Fm).
250 - 260	MUDSTONE	Dk brown to dk brownish red, traces v hard sandy black shale. (Redwater sh mbr Sundance Fm).
260 - 270	MUDSTONE	Lt. greenish gray and soft clay shale with lt. greenish gray hard sis. (Redwater sh mbr Sundance Fm)
270 - 280	MUDSTONE	As above. (Redwater sh mbr Sundance Fm)
280 – 290	MUDSTONE	Med greenish gray, clay rich with thin laminations of hard dk gray ms to sis. (Redwater sh mbr Sundance Fm)
290 - 300	MUDSTONE	Med brownish gray, clay rich with thin laminations of hard dk gray ms to sis. (Redwater sh mbr Sundance Fm)
300 - 310	SANDSTONE	V lt greenish gray to white, f grained, rounded friable – clay cemented. (Redwater sh mbr Sundance Fm)
310 - 320	CLAYSTONE	Dk gray, silty to sandy, occasional thin hard mudstone interbeds. (Redwater sh mbr Sundance Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
320 - 330	CLAYSTONE	As above. (Redwater sh mbr Sundance Fm)
330 - 340	CLAYSTONE	As above. (Redwater sh mbr Sundance Fm)
340 - 350	CLAYSTONE	As above. (Redwater sh mbr Sundance Fm)
350 - 360	CLAYSTONE	As above, v silty, almost siltstone, but too much clay. Probably shaley sis remolded by bit. (Redwater sh mbr Sundance Fm)
360 – 370	CLAYSTONE	Dk Gray, sandy, soft. (Redwater sh mbr Sundance Fm)
370 - 380	CLAYSTONE	As above. (Redwater sh mbr Sundance Fm)
380 - 390	SANDSTONE	Dk greenish gray, glauc, vf, qtz w/10% chert. (Redwater sh mbr Sundance Fm)
390 - 400	SANDSTONE	As above. (Redwater sh mbr Sundance Fm)
400 – 410	MUDSTONE	Dk Gray, soft, w/sandy sis laminae, stiff with clay, shaley sis or sis w/clay laminae. (Redwater sh mbr Sundance Fm)
410 - 420	MUDSTONE	As above, shaley sis or sis w/clay laminae, fissile. (Redwater sh mbr Sundance Fm)
420 - 430	MUDSTONE	As above. (Redwater sh mbr Sundance Fm)
430 - 440	MUDSTONE	As above. (Redwater sh mbr Sundance Fm)
440 - 450	MUDSTONE	As above. (Redwater sh mbr Sundance Fm)
450 - 460	MUDSTONE	As above, tr pyrite. (Redwater sh mbr Sundance Fm)
460 - 470	MUDSTONE	Dk gy, silty, includes 10% shalely sis. (Redwater sh mbr Sundance Fm)
470 - 480	MUDSTONE	As above. (Redwater sh mbr Sundance Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
480 - 490	MUDSTONE	As above. (Redwater sh mbr Sundance Fm)
490 - 500	MUDSTONE	As above. (Redwater sh mbr Sundance Fm)
500 - 510	SILTSTONE	Med gy, soft, shaley w/few hard cmtd dk gy sis layers. (Redwater sh mbr Sundance Fm)
510 - 520	SILTSTONE	As above. (Redwater sh mbr Sundance Fm)
520 - 530	SANDSTONE	Med – lt gy, vf, silty, hard, 10% soft white vf ss, clayey w/lt gy soft clay. Traces glauconite in hard sands. (Redwater sh mbr Sundance Fm)
530 - 540	SANDSTONE	White, vf qtz, rounded, soft w/white matrix, with lt greenish-gray soft clay. (Redwater sh mbr Sundance Fm)
540 - 550	SILTSTONE	Reddish brown, hard to soft sis, some vf sandy sis. (Redwater sh mbr Sundance Fm)
550 - 560	SILTSTONE	Shaley, 90% gray, soft, clayey sis & 10% whitish gray to lt reddish brown sis
560 - 570	SILTSTONE	Reddish brown to lt gray laminated, some clay content in sample. (Redwater sh mbr Sundance Fm)
570 - 580	SILTSTONE	As above. (Redwater sh mbr Sundance Fm)
580 - 590	SHALE	V lt gray, silty. soft clay shale w/silty layers or partings. (Redwater sh mbr Sundance Fm)
LAK Member of Sundance Formation - Top 580 feet		
590 - 600	SANDSTONE	V lt gy, vf, qtz, rounded, v soft/friable. (LAK mbr Sundance Fm)
600 - 610	ANHYDRITE	White, massive. (LAK mbr Sundance Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
610 - 620	SANDSTONE	V lt gray, vf, qtz, rounded, white cmt. (LAK mbr Sundance Fm)
Hulett Sandstone Member of Sundance Formation - Top 621 feet		
620 - 630	SANDSTONE	As above. (Hulett ss mbr Sundance Fm)
630 – 640	NO SAMPLE	Contact picked from GAMMA RAY and E-Logs. (Hulett ss mbr Sundance Fm)
Stockade-Beaver Shale Member of Sundance Formation - Top 644 feet		
640 - 650	NO SAMPLE	NO SAMPLE. (Stockade Beaver sh mbr Sundance Fm)
650 - 660	NO SAMPLE	NO SAMPLE. (Stockade Beaver sh mbr Sundance Fm)
660 - 670	SILTSTONE	Dk gray, and dk gray silty mudstone, shalely sis. (Stockade Beaver sh mbr Sundance Fm)
670 - 680	SILTSTONE	Dk gray, trace fissile shale. (Stockade Beaver sh mbr Sundance Fm)
680 - 690	SILTSTONE	Dk gray, trace fissile shale. (Stockade Beaver sh mbr Sundance Fm)
690 - 700	SANDSTONE	Lt to med gray sandstone, vf-fine, subround to angular, moderately sorted, slightly calcareous. , (Stockade Beaver sh mbr Sundance Fm)
700 - 710	MUDSTONE	Silty, v dark gray, hard, fissile, to very soft. (Stockade Beaver sh mbr Sundance Fm)
710 - 720	MUDSTONE	As Above. (Stockade Beaver sh mbr Sundance Fm)
720 - 730	MUDSTONE	As Above. (Stockade Beaver sh mbr Sundance Fm)
730 - 740	NO SAMPLE	NO SAMPLE
740 - 750	NO SAMPLE	NO SAMPLE

Sample Depth Interval (feet BGL)	Lithology	Description
		Spearfish Formation Top 754 ft.
		Note: The soft siltstones and silty mudstones throughout the Spearfish Fm. appear to be weakly cemented with calcareous cement, samples return as a silty mud slurry with occasional competent chips, which when cleaned and a fresh faced opened, weakly effervesce with 10% HCl. However, the majority of silty-mud slurry will violently effervesce. It appears that the siltstone/mudstone/drilling fluid slurry contains significant amounts of calcareous material, apparently as a byproduct of pulverization of the parent material by the bit. The hard (well indurated) sandstones and siltstones do not effervesce and do not indicate calcareous cement.
750 - 760	NO SAMPLE	Contact picked from GAMMA RAY and E-Logs.
760 - 770	MUDSTONE	Dk red, silty. Occasional med gray claystone interbeds (Spearfish Fm.)
770 - 780	MUDSTONE	As above, includes a few laminae of hard, red, gypsiferous, sis and anhydrite. (Spearfish Fm.)
780 - 790	SILTSTONE	Dk red, visible gypsum on partings, occasional med gray claystone interbeds. (Spearfish Fm.)
790 - 800	MUDSTONE	Dk red, silty. soft (Spearfish Fm.)
800 - 810	SILTSTONE	Dk red, visible gypsum on partings, occasional med gray claystone interbeds. (Spearfish Fm.)
810 - 820	SILTSTONE	As above. (Spearfish Fm.)
820 - 830	SILTSTONE	As above. (Spearfish Fm.)
830 - 840	SILTSTONE	Dk red, mixture of hard and soft (~50/50), soft sis has visible gypsum on partings & in pores. Occasional 1-2mm nodules of gypsum. (Spearfish Fm.)
840 - 850	SILTSTONE	As above. (Spearfish Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
850 - 860	SILTSTONE	As above. (Spearfish Fm.)
860 - 870	SILTSTONE	Dk red, poorly indurated, weakly calcareous, minor med gray claystone interbeds. (Spearfish Fm.)
870 - 880	MUDSTONE	Dk red, silty with thin, hard sis laminations. weakly calcareous (Spearfish Fm.)
880 - 890	MUDSTONE	As above. (Spearfish Fm.)
890 - 900	SILTSTONE	Dk red mixture of hard and soft (~60/40), soft sis has visible gypsum on partings. Weakly calcareous (Spearfish Fm.)
900 - 910	MUDSTONE	Dk red, silty w/ 20% thinly laminated hard sis, thin dark gray claystone laminations, Minor gypsum. (Spearfish Fm.)
910 - 920	MUDSTONE	As above (Spearfish Fm.)
920 - 930	SILTSTONE	Dk red mixture of hard and soft (~40/60), soft sis has visible gypsum on partings. Weakly calcareous (Spearfish Fm.)
930 - 940	MUDSTONE	Dk red, silty. Weakly calcareous (Spearfish Fm.)
940 - 950	SILTSTONE	Dk red, medium to well indurated. (Spearfish Fm.)
950 - 960	SILTSTONE	Dk red, well indurated. (Spearfish Fm.)
960 - 970	SILTSTONE	As above. (Spearfish Fm.)
970 - 980	SILTSTONE	As above. (Spearfish Fm.)
980 - 990	MUDSTONE	Dk red, silty, common gypsum nodules along partings. Thin, hard sis laminations. Samples wash away to just hard siltstone if not careful during sample prep. Weakly calcareous. (Spearfish Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
990 - 1000	MUDSTONE	As above. (Spearfish Fm.)
1000 - 1010	MUDSTONE	As above. (Spearfish Fm.)
1010 - 1020	SILTSTONE	Dk red, predominantly well indurated with thin dk gray claystone interbeds. (Spearfish Fm.)
1020 - 1030	SILTSTONE	As above. (Spearfish Fm.)
1030 - 1040	NO SAMPLE	No SAMPLE
1040 - 1050	SILTSTONE	Dk red, silty, common gypsum nodules and minor anhydrite along partings, ≈20% clay content in MS. Thin, hard sis laminations. Weakly calcareous (Spearfish Fm.)
1050 - 1060	SILTSTONE	Dk red, predominantly well indurated with thin dk gray claystone interbeds. (Spearfish Fm.)
1060 - 1070	MUDSTONE	Dk red,silty, occasional gypsum and anhydrite.20-25% clay content. Weakly calcareous (Spearfish Fm.)
1070 - 1080	SILTSTONE	Dk red, occasional gypsum and anhydrite. 20-25% clay content; Weakly calcareous (Spearfish Fm.)
1080 - 1090	SILTSTONE	As above. (Spearfish Fm.)
1090 - 1100	SILTSTONE	As above. (Spearfish Fm.)
1100 - 1110	SILTSTONE	As above. (Spearfish Fm.)
1110 - 1120	SILTSTONE	As above. (Spearfish Fm.)
1120 - 1130	SILTSTONE	As above. (Spearfish Fm.)
1130 - 1140	MUDSTONE	Dk red,silty. (Spearfish Fm.)
1140 - 1150	MUDSTONE	As above. (Spearfish Fm.)

TEST WELL #2A - GILLETTE MADISON PIPELINE PROJECT

Sample Depth Interval (feet BGL)	Lithology	Description
1150 - 1160	SILTSTONE	Dk red, moderately hard, abundant gypsum. (Spearfish Fm.)
1160 - 1170	MUDSTONE	Dk red,silty. (Spearfish Fm.)
1170 - 1180	MUDSTONE	Dk red,silty 20% clay content. (Spearfish Fm.)
1180 - 1190	ANHYDRITE	White to rose, massive finely crystalline with interbedded Dk red, soft sis. (Spearfish Fm.)
1190 - 1200	CLAYSTONE	Dk gray, massive hard with Dk red ms at base (Spearfish Fm.)
1200 - 1210	MUDSTONE	Dk red,silty. (Spearfish Fm.)
1210 - 1220	MUDSTONE	Dk Red silty, approx. 20% clay content. (Spearfish Fm.)
1220 - 1230	MUDSTONE	Dk Red silty, 15%. abundant gypsum (10-15%). (Spearfish Fm.)
1230 - 1240	ANHYDRITE	Lt tan to white, translucent to opaque, finely crystalline, with thin white gypsum (10%) and med gray claystone interbeds. (Spearfish Fm.)
1240 - 1250	ANHYDRITE	As above. (Spearfish Fm.)
1250 - 1260	MUDSTONE	Dk red,silty 20% clay content. (Spearfish Fm.)
1260 - 1270	MUDSTONE	As above (Spearfish Fm.)
1270 - 1280	MUDSTONE	Dk red,silty. (Spearfish Fm.)
1280 - 1290	MUDSTONE	As above. (Spearfish Fm.)
1290 - 1300	MUDSTONE	Dk, red, silty thin, hard dk red sis. (Spearfish Fm.)
1300 - 1310	MUDSTONE	Dk red,silty. (Spearfish Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
1310 - 1320	MUDSTONE	Dk red, silty, clay rich (~20-25%) with 10% gypsum. (Spearfish Fm.)
1320 - 1330	MUDSTONE	Dk red hard 70/30 mixture of hard and soft with minor, thin med gray claystone and minor gypsum lamintations. (Spearfish Fm.)
1330 - 1340	MUDSTONE	As above. (Spearfish Fm.)
1340 - 1350	MUDSTONE	As above. (Spearfish Fm.)
1350 - 1360	SILTSTONE	Dk red, minor white gypsum. (Spearfish Fm.)
1360 - 1370	SILTSTONE	As above. (Spearfish Fm.)
1370 - 1380	SILTSTONE	As above. (Spearfish Fm.)
1380 - 1390	MUDSTONE	Lt gray mudstone with interebbed well indurated siltstone, v. calcareous (Spearfish Fm.)
1390 - 1400	MUDSTONE	As above. (Spearfish Fm.)
		Minnekahta Limestone Formation -Top 1394 feet
1400 - 1410	LIMESTONE	Lt to medium tan, massive, aphanitic with local euhedral secondary crystallization of calcite and pyrite. Oil staining and seepage from pores and fractures. decreasing with depth. (Minnekahta Fm.)
1410 - 1420	LIMESTONE	Lt to medium tan, massive, aphanitic with local euhedral secondary crystallization of calcite and pyrite. Minor oil staining and seepage. (Minnekahta Fm.)
1420 - 1430	LIMESTONE	Lt greenish gray, massive, aphanitic with local euhedral secondary crystallization of calcite and pyrite. Minor oil staining and seepage. (Minnekahta Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
		Opeche Shale Formation - Top 1432 feet
1430 - 1440	SILTSTONE	Dk purplish red, mixture of hard and soft, 70/30 respectively. (Opeche Fm.)
1440 - 1450	MUDSTONE	Reddish orange, silty with thinly laminated dk red, well indurated sis with trace fracture fill anhydrite. (Opeche Fm.)
1450 - 1460	MUDSTONE	Dk red, silty with thinly laminated, well indurated sis with trace fracture fill anhydrite. (Opeche Fm.)
1460 - 1470	MUDSTONE	Reddish orange, silty with thinly laminated dk red, well indurated sis with trace fracture fill anhydrite. (Opeche Fm.)
1470 - 1480	MUDSTONE	Dk red, silty with thinly laminated, well indurated sis. (Opeche Fm.) trace fracture fill anhydrite
1480 - 1490	MUDSTONE	Dk red, silty with thinly laminated, well indurated sis. (Opeche Fm.) trace fracture fill anhydrite
1490 - 1500	MUDSTONE	Dk red, silty with thinly laminated, well indurated sis. (Opeche Fm.) trace fracture fill anhydrite
1500 - 1510	MUDSTONE	Dk red, silty with thinly laminated, well indurated sis. (Opeche Fm.) trace fracture fill anhydrite.
		Minnelusa Formation - Top 1508 feet
1510 - 1520	SANDSTONE	Lt greenish gray, vf to silt, subrnd to rnd, well sorted quartzose, 5% chert. Slightly calcareous. (Minnelusa Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
1520 - 1530	SANDSTONE	Dk gray vf to f, sub-rnd to angular, qtzose, weakly calcite cemented, friable, porous. Oil stains in pores. Minor dissem. pyrite. Calcite cement highly reactive, but dry samples extrude gypsum, indicating anhydrite is present in sandstone matrix and becoming hydrated in the samples, thus appearing as gypsum crusts and/or dendritic crystals. (Minnelusa Fm.)
1530 - 1540	SANDSTONE	As above. (Minnelusa Fm.)
1540 - 1550	SANDSTONE	As above. (Minnelusa Fm.)
1550 - 1560	SANDSTONE	As above. (Minnelusa Fm.)
1560 - 1570	SANDSTONE	Lt tannish gray and dk gray vf to f sub round to angular, qtzose, weakly calcite cemented minor pyrite dk gray attributable to interstitial oil. Dry samples extrude gypsum. (Minnelusa Fm.)
1570 - 1580	SANDSTONE	As above. (Minnelusa Fm.)
1580 - 1590	SANDSTONE	As above. (Minnelusa Fm.)
1590 - 1600	SILTSTONE	Tan to lt gray, well indurated, calcite vein fillings. Minor oil coating on fracture faces. (Minnelusa Fm.)
1600 - 1610	SILTSTONE	As above, light gray. (Minnelusa Fm.)
1610 - 1620	SILTSTONE	As above, tan more frequent oil staining and occasional oil in fractures that are not filled with calcite. (Minnelusa Fm.)
1620 - 1630	SILTSTONE	As above. (Minnelusa Fm.)
1630 - 1640	GYPSUM	Lt greenish gray, soft massive. (Minnelusa Fm.)
1640 - 1650	ANHYDRITE	White to greenish white to rose, finely crystalline, massive. (Minnelusa Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
1650 - 1660	ANHYDRITE	As above. (Minnelusa Fm.)
1660 - 1670	DOLOMITE	Tan to greenish tan, finely crystalline common pyrite concretions. (Minnelusa Fm.)
1670 - 1680	SANDSTONE	White to med gray, vf to f grained, subrounded qtzose, well sorted. Weakly anhydrite cemented. (Minnelusa Fm.)
1680 - 1690	SANDSTONE	Med to dk gray vf to f, well rounded, qtzose, possibly anhydrite cemented but harder than above, locally contains crystalline dolomite concretions. Abundant oil in pores and fractures. (Minnelusa Fm.)
1690 - 1700	SANDSTONE	As above. (Minnelusa Fm.)
1700 - 1710	SANDSTONE	As above. (Minnelusa Fm.)
1710 - 1720	SANDSTONE	As above. (Minnelusa Fm.)
1720 - 1730	SANDSTONE	White to med gray, vf to f grained, subrounded qtzose, well sorted. Weakly anhydrite cemented. (Minnelusa Fm.)
1730 - 1740	SANDSTONE	As above. (Minnelusa Fm.)
1740 - 1750	SANDSTONE	Lt greenish gray, vf, sub rnd, well cemented, hard. (Minnelusa Fm.)
1750 - 1760	SANDSTONE	Med gray, vf, sub rnd, weakly cemented, interbedded with minor gypsum and minor mudstone. (Minnelusa Fm.)
1760 - 1770	SANDSTONE	White to med gray, vf to f grained, subrounded qtzose, well sorted. Weak calcite cement as well as anhydrite in matrix. (Minnelusa Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
1770 - 1780	SANDSTONE	Medium gray, fine-grained, qtzose with subangular clear qtz, gypsum matrix, cuttings come up as rounded "B-B shot" in thick gypsum slurry. Gypsum from soft matrix of sandstone. (Minnelusa Fm.)
1780 - 1790	SANDSTONE	As above (Minnelusa Fm.)
1790 - 1800	ANHYDRITE	Medium to light gray, includes some crystals of dolomite and a few thin, hard vfs layers with pyrite, some anhydrite contains up to 5% vfs grains. (Minnelusa Fm.)
1800 - 1810	SANDSTONE	Med. gray, vf, qtzose, hard with anhydrite(?) cement. Parts of sample may be silty dolomite. (Minnelusa Fm.)
1810 - 1820	SANDSTONE/ DOLOMITE	As above, mostly vf, traces ms w/pyrite, dolomite cemented, few cuttings of lt. gray anhydrite. Sample collected while drilling 1811-1812 feet was very hard qtzose sandstone. Sample collected from 1811-1816 feet, was 90% hard, mxtln dolomite, few dolomite fracture fillings. (Minnelusa Fm.)
1820 - 1830	SANDSTONE	White, vf, quartz ss, gypsum cement, 30% cuttings include oil stains in pores, cuttings in gray slurry of ground up gypsum. (Minnelusa Fm.)
1830 - 1840	DOLOMITE	Lt. gray, mxtln, hard, with 10% vf qtz ss with white dolomite cement, usually discontinuously stained with black oil, but no oil on water or sample bag. (Minnelusa Fm.)
1840 - 1850	SANDSTONE/ DOLOMITE	Lt. to med. gray, vf, quartz ss, hard w/dolomite cement, 5-10% mxtln dolomite in sample. (Minnelusa Fm.)
1850 - 1860	ANHYDRITE	White to nearly translucent clear, massive. (Minnelusa Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
1860 - 1870	SANDSTONE	White, quartz ss w/dolomite cement, mixed with 10% amorphous anhydrite and 40-50% soft, silty, reddish-brown clay. This is red marker at bottom of upper Minnelusa. (Minnelusa Fm.)
1870 - 1880	SANDSTONE	White tan and gray, quartz ss. (Minnelusa Fm.)
1880 - 1890	ANHYDRITE	Pinkish gray, opaque to translucent, massive. (Minnelusa Fm.)
1890 - 1900	SANDSTONE	Med gray, vf to f. (Minnelusa Fm.)
1900 - 1910	SANDSTONE	As above, weakly calcareous (Minnelusa Fm.)
1910 - 1920	SANDSTONE	Tan, vf grained, dolomite cemented moderately hard with 10% bluish gray clay cemented SS, poorly indurated, abundant pyrite (Minnelusa Fm.)
1920 - 1930	SANDSTONE	As above. (Minnelusa Fm.)
1930 - 1940	SANDSTONE	As above. (Minnelusa Fm.)
1940 - 1950	SILTSTONE	Bluish gray to black, moderately hard. (Minnelusa Fm.)
1950 - 1960	SANDSTONE	Med gray, vf grained, weakly indurated. With 50% dk red clay rich mudstone. (Minnelusa Fm.)
1960 - 1970	SANDSTONE	White to lt greenish gray, vf grained, hard, weakly calcareous. (Minnelusa Fm.)
1970 - 1980	SANDSTONE	As above. (Minnelusa Fm.)
1980 - 1990	SANDSTONE	Med gray, vf grained, weakly indurated. With 50% dk red clay rich mudstone. (Minnelusa Fm.)
1990 - 2000	ANHYDRITE	Tannish gray to rose, opaque massive. (Minnelusa Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
2000 - 2010	SILTSTONE & CLAYSTONE	Lt green sis with 10% vf sand, poorly indurated and silty to sandy pink claystone. 50/50. (Minnelusa Fm.)
2010 - 2020	MUDSTONE & SANDSTONE	Red clay rich ms with lt tan vf to f sandstone. (Minnelusa Fm.)
2020 - 2030	MUDSTONE	Red with 10% lt tan sis to ss. (Minnelusa Fm.)
2030 - 2040	MUDSTONE	As above. (Minnelusa Fm.)
2040 - 2050	SILTSTONE	White to lt gray, hard. (Minnelusa Fm.)
2050 - 2060	SILTSTONE	As above. (Minnelusa Fm.)
2060 - 2065	SILTSTONE	Lt to med gray, with interbedded white to grayish white claystone and minor dolomite. (Minnelusa Fm.)
2065 - 2070	DOLOMITE	Med gray, finely crystalline. (Minnelusa Fm.)
2070 - 2075	ANHYDRITE	White to rose with crystalline dolomite fracture filling. (Minnelusa Fm.)
2075 - 2080	MUDSTONE	Red with 10% med gray ss and 10% dk red mudstone. (Minnelusa Fm.)
2080 - 2085	MUDSTONE	As above. (Minnelusa Fm.)
2085 - 2090	DOLOMITE	Lt tan mxtln with minor lit green claystone. (Minnelusa Fm.)
2090 - 2095	DOLOMITE & CLAYSTONE	Lt tan mxtln and soft white claystone 50/50. (Minnelusa Fm.)
2095 - 2100	SILTSTONE & CLAYSTONE	Dk red siltstone and red claystone 50/50. (Minnelusa Fm.)
2100 - 2105	LIMESTONE	Dk grayish brown, mxtln. (Minnelusa Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
2105 - 2110	LIMESTONE	Dk grayish brown, mxtln with 10% orange chert. (Minnelusa Fm.)
2110 - 2115	DOLOMITE	Dk grayish brown, mxtln with minor white, translucent dolomite fracture fill. (Minnelusa Fm.)
2115 - 2120	DOLOMITE	Med tannish gray, mxtln. (Minnelusa Fm.)
2120 - 2125	DOLOMITE	As above. (Minnelusa Fm.)
2125 - 2130	DOLOMITE	Dk grayish brown, mxtln with minor white. (Minnelusa Fm.)
2130 - 2135	DOLOMITE	Dk grayish brown, mxtln with minor white, translucent dolomite fracture fill. (Minnelusa Fm.)
2135 - 2140	DOLOMITE	As above (Minnelusa Fm.)
2140 - 2145	DOLOMITE	As above (Minnelusa Fm.)
2145 - 2150	DOLOMITE	Lt tan mxtln to coarsely xtln, calcite fracture fill and minor maroon mudstone. (Minnelusa Fm.)
2150 - 2155	DOLOMITE	As above. (Minnelusa Fm.)
2155 - 2160	ANHYDRITE	Rose, massive. (Minnelusa Fm.)
2160 - 2165	DOLOMITE	Tan to pinkish, mxtln and minor anhydrite. (Minnelusa Fm.)
2165 - 2170	DOLOMITE	Tan to pinkish, mxtln and minor pink and lt green claystone. (Minnelusa Fm.)
2170 - 2175	MUDSTONE	Maroon to lt green silty, hard, minor tan to pinkish dolomite and soft white claystone. (Minnelusa Fm.)
2175 - 2180	SILTSTONE & MUDSTONE	Med gray to maroon to lt green and pink to tan to white claystone. 50/50. (Minnelusa Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
2180 - 2185	SILTSTONE & MUDSTONE	As above with 60/40 cs to sis. (Minnelusa Fm.)
2185 - 2190	MUDSTONE	Orange clay-rich with white friable ss (probably at from next interval). (Minnelusa Fm.)
2190 - 2195	SANDSTONE	Pinkish white, vf to f, sub ang to rnd, friable to weakly cemented (Minnelusa Fm.)
2195 - 2200	SANDSTONE	White, f to m, sub ang to rnd, weak to moderately cemented, weakly calcareous. (Minnelusa Fm.)
2200 - 2205	SANDSTONE	AA with 10-15% maroon and greenish gray mudstone. (Minnelusa Fm.)
2205 - 2210	CLAYSTONE	Dk red with 10% white ss. (Minnelusa Fm.)
2210 - 2215	CLAYSTONE & SANDSTONE	As above with 50/50 cs to ss. (Minnelusa Fm.)
2215 - 2220	SANDSTONE	White, occasional orange and purple mottling, f to m, sub ang to rnd, weak to moderately cemented, weakly calcareous. (Minnelusa Fm.)
2220 - 2225	SANDSTONE	As above with 10% red claystone. (Minnelusa Fm.)
2225 - 2230	CLAYSTONE	Red claystone with minor thin dk red ms interbeds. (Minnelusa Fm.)
2230 - 2235	MUDSTONE	Dk red, sandy, clay rich mudstone and with white ss. (Minnelusa Fm.)
2235 - 2240	SANDSTONE	White to tan occasional orange and purple mottling, f to m, sub ang to rnd, weak to moderately cemented, weakly calcareous. (Minnelusa Fm.)
2240 - 2245	SANDSTONE	As above. (Minnelusa Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
2245 - 2250	SANDSTONE	As above. (Minnelusa Fm.)
2250 - 2255	SANDSTONE	White occasional orange and purple mottling, f to m, sub ang to rnd, weak to moderately cemented, weakly calcareous. (Minnelusa Fm.)
2255 - 2260	SANDSTONE	As above. (Minnelusa Fm.)
2260 - 2265	SANDSTONE	As above. (Minnelusa Fm.)
2265 - 2270	SANDSTONE	As above. (Minnelusa Fm.)
2270 - 2275	SANDSTONE & CLAY	White, m, subrnd to rounded, friable, quartz ss w/discontinuous gypsum cement, interbedded with about 30% soft reddish brown,sticky, clay. (Minnelusa Fm.)
2275 - 2280	SANDSTONE & CLAY	As above, but sand all friable and broke down to single qtz grains. Estimate 20-30% reddish brown clay interbedded with sandstone. (Minnelusa Fm.)
2280 - 2285	CLAY	Reddish-bn, v. stky, interbedded w/10% medium qtz ss w/gypsum cement, traces rhombohedral black accessory mineral, probably goethite. (Minnelusa Fm.)
2285 - 2290	CLAY	As above. (Minnelusa Fm.)
2290 - 2295	CLAY	As above. (Minnelusa Fm.)
2295 - 2300	CLAY	As above. (Minnelusa Fm.)
2300 - 2305	CLAY	As above, 20% ss. (Minnelusa Fm.)
2305 - 2310	SANDSTONE	White, qtz, m, subrnd to rounded, friable, gypsum cemented, intbbd w/30% pale yellow-brown clay. (Minnelusa Fm.)
2310 - 2315	CLAY	Reddish-bn, v. stky, , interbedded w/10% medium qtz ss w/gypsum cement. (Minnelusa Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
2315 - 2320	SANDSTONE	White to medium gray, qtz, f-m, subrnd to rounded, hard, cemented w/gypsum, intbbd w/20% reddish-bn clay, 1% m qtz ss, cemented w/hard, black iron oxide. (Minnelusa Fm.)
2320 - 2325	SANDSTONE	As above. (Minnelusa Fm.)
2325 - 2330	SANDSTONE	Grayish-white, black mottled, qtz ss, m, subrnd to rounded, hard, cemented w/gypsum and discontinuous hard, black iron oxide, intbdded w/15% reddish-bn clay, (Minnelusa Fm.)
2325 - 2334	SANDSTONE	As above. (Minnelusa Fm.)
2334 - 2342	LIMESTONE	Medum gray to greenish-gray, recrystallized (de-dolomitized?) sparry calcite w/few cleavage faces and 1-2% brown iron oxide cemented areas 3-5 mm in size. About 10% of samples exhibit vuggy porosity between calcite crystals. (Minnelusa Fm.)
2342 - 2345	CLAY	Reddish-bn, v. stky, soft, intbbd w/10-30% white gypsiferous, m qtz sandstone. (Minnelusa Fm.
2345 - 2350	CLAY	As above. (Minneslusa Fm.)
2350 - 2355	CLAY	As above. (Minneslusa Fm.)
2355 - 2360	CLAY	As above. (Minneslusa Fm.)
2360 - 2365	DOLOMITE	Greenish-gray, with 2% clear calcite secondary fillings, 1-2% black iron oxide (goethite?) cemented fragments, 2-5% soft gray clay. (Minnelusa Fm.)
2365 - 2370	CLAY	Pale reddish-brown, soft, sticky, with 20-30% white, soft gypsum and 2-3% hard greenish-gray microcrystalline limestone. (Minnelusa Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
		Madison Group Formation - Top 2370 feet
2370 - 2375	DOLOMITE	Approx. 20% pale yellowish white mxtln dolomite and 80% bluish to brownish gray, coarsely xtln (1-2 mm crystals) dolomite with many distinct crystals evident and a few porous crystalline pieces. Highly recrystallized for the most part. (Madison Group)
2375 - 2380	DOLOMITE	As above, but mostly greenish-gray overall appearance with 10% brown to reddish-brown, coarse, recrystallized limestone with some crystals 5-6 mm in mean size. Highly recrystallized dolomite with minor recrystallized limestone or dedolomitized dolomite. (Madison Group)
2380 - 2385	DOLOMITE	Greenish-gray, mxtln, massive, with 25% recrystallized dolomite and 5% soft grayish-white clay. (Madison Group)
2385 - 2390	DOLOMITE	Lt. greenish-gray, mxtln, massive. Up to 1% 0.02-mm distinctive individual disseminated pyrite crystals or hematite after pyrite in about 50% of cuttings. Traces of larger hematite psuedomorphs of pyrite in a few cuttings. (Madison Group)
2390 - 2400	LIMESTONE	Brown, finely crystalline limestone (sparite). Trace brownish-red chert. (Madison Group)
2400 - 2410	DOLOMITE	Medium gray, finely crystalline (dolosparite) comprises 90% of cuttings, 10% brown and reddish-brown sparite. (Madison Group).
2410 - 2420	DOLOMITE	Medium gray, white and reddish-brown, fine to medium crystalline, with porosity consisting of 2-3% round solution holes less than 1 mm in diameter. 80% of sample reduces to coarse-sand sized cuttings. (Madison Group).
2420 - 2430	DOLOMITE	Light gray, v. fine to medium crystalline. (Madison Group)

Sample Depth Interval (feet BGL)	Lithology	Description
2430 - 2440	DOLOMITE	Medium gray with 20% brownish-gray, all fine to medium crystalline, about 10% of cuttings exhibit solution conduit porosity as in sample above, cuttings mostly reduce to sand-sized and granular fragments. (Madison Group)
2440 - 2450	DOLOMITE	As above. Some of the solution conduit porosity exhibits rectangular cross sections where mineral crystals have been dissolved out of the rock. (Madison Group).
2450 - 2460	DOLOMITE	Light gray to white, finely crystalline dolosparite, 100% of sample broken down to 1-2 mm fragments or smaller, trace vf red qtz ss and trace red clay. (Madison Group)
2460 - 2470	DOLOMITE	As above. Some cutting fragments up to 5 mm. (Madison Group)
2470 - 2480	DOLOMITE	As above. Some cutting fragments up to 5 mm. (Madison Group)
2480 - 2490	DOLOMITE	As above. Some cutting fragments up to 5 mm. (Madison Group)
2490 -2500	DOLOMITE	As above. Some cutting fragments up to 5 mm. (Madison Group)
2500 - 2510	DOLOMITE	As above. Some cutting fragments up to 5 mm. (Madison Group)
2510 - 2520	DOLOMITE	As above. Some cutting fragments up to 5 mm. (Madison Group)
2520 - 2530	DOLOMITE	As above. Some cutting fragments up to 5 mm. (Madison Group)
2530 - 2540	DOLOMITE	As above. 1% reddish-brown chert. (Madison Group).

Sample Depth Interval (feet BGL)	Lithology	Description
2540 - 2550	DOLOMITE	Same as 2450 to 2540. Some cutting fragments up to 5 mm. Few larger cuttings reveal up to 10% solution hole (secondary) porosity. (Madison Group)
2550 - 2560	DOLOMITE	As above. (Madison Group).
2560 - 2570	DOLOMITE	Lt to med gy, vf xtln dolosparite, rock mass all porous on very small scale, easily soaking up applied water. About 10% of sample is harder, dark gray sparite. This makes normal cuttings and does not break down to sand sized fragments. (Madison Group).
2570 - 2580	DOLOMITE	Light to medium gray, very finely crystalline to lime pellets with white halos; porosity often in pellets and ringed by white crystal, some pieces almost oolitic; but not round like oolites, (Madison Group).
2580 - 2590	DOLOMITE	Dark gray, v. finely crystalline dolosparite, only 1-2% obviously porous rock, cuttings tend to be tabular. (Madison Group).
2590 - 2600	DOLOMITE	80% Dark gray, v. fine dolosparite with low porosity and 20% light gray fine dolosparite with 2-3% secondary porosity. (Madison Group).
2600 - 2610	DOLOMITE	Dark gray, fine – med dolosparite with trace pyrite, 1-3% porosity with few pieces up to 15% porosity. (Madison Group).
2610 - 2620	DOLOMITE	Dark gray, finely xtln dolosparite, about 20% dark gray finely xtln limestone (micrite). Some dolomite fractured with clear fracture filling, few pieces with white calcite fracture filling on one side. (Madison Group).
2620 - 2630	DOLOMITE	As above. (Madison Group).
2630 - 2640	DOLOMITE	Med. gray, hard, recrystallized, no porosity evident. (Madison Group).

Sample Depth Interval (feet BGL)	Lithology	Description
2640 - 2650	DOLOMITE	As above. (Madison Group).
2650 - 2660	DOLOMITE	Dark gray fine-med xtln dolosparite with a few cemented fractures and purple mottling on fracture faces, no porosity evident. (Madison Group).
2660 - 2670	DOLOMITE	As above. 3-4 mm or smaller cuttings, so cannot see if porous. (Madison group).
2670 - 2680	DOLOMITE	Lt. brownish-gray, v. finely xtln dolosparite, very little open porosity evident but rock soaks up water. 2-3% reddish-brown chert. (Madison Group).
2680 - 2690	DOLOMITE	Lt. brownish-gray to white, fine-med. xtln dolosparite with evident porosity. 2-3% clear calcite in sample. (Madison Group).
2690 - 2700	DOLOMITE	Ltbrownish-gray, mostly v. finely xtln dolosparite with very little evident porosity in large cuttings (3-6 cm). (Madison Group).
2700 -2710	DOLOMITE	As above with most cuttings less than 4 mm. (Madison Group).
2710 - 2720	DOLOMITE	50% Dk. gray v. finely xtln dolosparite with no evident porosity an 50% grayish-white oolitic dolomite with good porosity. (Madison Group).
2720 - 2730	DOLOMITE	As above, oolitic dolomite partially recrystallized with clear rectangular crystals. (Madison Group).
2730 - 2740	DOLOMITE	Grayish-white oolitic dolomite without recrystallization evident in previous sample, good porosity. (Madison Group)
2740 - 2750	DOLOMITE	As above. (Madison Group).

Sample Depth Interval (feet BGL)	Lithology	Description
2750 - 2760	DOLOMITE	Dk. gray, v. finely xtln dolosparite with no evident porosity. (Madison Group).

NO SAMPLES FROM 2760 TO 2848 FEET – cyclone blew up so could not use shale shakers. Routed air lift discharge directly through 10-inch dump line to waste. Decided it was too dangerous to try to collect samples from 6740-CFM air stream on steep slope in the dark so continued drilling without collecting samples. Resumed sampling in the daylight when could see properly.

Whitewood Dolomite and Winnipeg Formation - Top 2752 feet
Formation top picked from short and long normal resistivity log

2848 - 2849	DOLOMITE	Medium gray, dolosparite with good porosity. (Whitewood Dolomite).
2850 - 2860	DOLOMITE	Dark gray, dolosparite. 50% of sample exhibits solution conduit porosity with black stains. Few cuttings of hard, light green shale in sample indicate top of Winnipeg Formation hit near bottom of this 10-foot interval. (Whitewood Dolomite)

Deadwood Formation - Top 2862 feet
Formation top picked from short and long normal resistivity log

2860 - 2870	SHALE AND SILTSTONE	Dk. gray siltstone, light green silty shale and reddish-brown ferrunginous sis in nearly equal amounts, black stains within many pieces. (Deadwood Formation)
2870 - 2880	QUARTZITE	Dk. brownish gray, fine-med grained quartzite. (Deadwood Formation)
2880 - 2890	QUARTZITE	Grayish-brown to slightly reddish-brown, mostly medium-grained, hard quartzite. (Deadwood Formation)

TD = 2891 Feet