APPENDIX C

Drill Cutting Lithologic Log and Geologic Classification
Test Well #1 (M-11)

MORRISON-MAIERLE, INC.
DRILL CUTTING SAMPLE DESCRIPTIONS

TEST WELL #1 - GILLETTE MADISON PIPELINE PROJECT

Sample Depth Interval (feet BGL)	Lithology	Description
		Lower Fall River Sandstone – Mudstone Unit **Top of Formation Truncated by Land Surface**
0 - 10	SILTSTONE	Light brown, laminated with few carbonaceous partings, highly weathered. (lower Fall River Fm., mudstone unit).
10 - 20	CLAYSTONE	Dark gray to black, soft, shalely with laminae of light brown siltstone, all weathered and soft. Few ledges hard sandy siltstone. (lower Fall River Fm., mudstone unit)
20 - 30	CLAYSTONE	Dark gray, silty, shaley with siltstone laminae. (lower Fall River Fm., mudstone unit).
30 - 40	CLAYSTONE	Dark gray to black silty, shalely with few beds light gray laminated siltstone, few 5-mm thick hard black coal seams. (lower Fall River Fm., mudstone unit).
		Lower Fall River Sandstone – Siltstone Unit – Top 40 feet
40 - 50	SILTSTONE	Dark gray, carbonaceous, shaley. (lower Fall River Fm., siltstone unit).
50 - 60	CLAYSTONE	Dark gray, shalely, intercolated with light gray, sandy, siltstone. (lower Fall River Fm., siltstone unit).
60 - 70	SILTSTONE	Dark gray, shaley, hard. (lower Fall River Fm., siltstone unit).
		Lakota Formation – upper part – Top 70 feet
70 - 80	CLAYSTONE	Dark gray, shaley, with minor light gray siltstone. (upper Lakota Fm.)
90 - 100	MUDSTONE	Bluish-gray to dark gray, shaley, minor laminated siltstone with carbonaceous partings. (upper Lakota Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
100 - 110	MUDSTONE	Medium to dark gray, shaley, very silty and sandy. (upper Lakota Fm.)
110 - 120	CLAYSTONE	As above. (upper Lakota Fm.)
120 - 130	SANDSTONE	Light gray, ms, subangular. to subrounded quartz ss, 4-5% pyrite, all loose sand in cuttings. (upper Lakota Fm.)
130 - 140	SANDSTONE	Light gray, ms, subrounded to rounded quartz ss, all loose sand in cuttings. (upper Lakota Fm.)
140 - 150	SANDSTONE	As above. (upper Lakota Fm.)
	Lakota Formation – basal sandstone unit – Top 147 feet	
150 - 160	CLAYSTONE	Light gray with conglomerate lens consisting of highly polished black chert and clear quartz pebbles up to 6 mm mean size, 4-5% pyrite concretions up to 4 mm in size. (upper Lakota Fm.)
160 - 170	SANDSTONE	White to light gray, f-m, rounded, quartz ss, with 15% of sample medium-grained angular quartz ss with 10-95% pyrite cement. (lower Lakota Fm.)
170 - 180	SANDSTONE	Medium gray, vfs, all sample loose sand. (lower Lakota Fm.)
180 - 190	SANDSTONE	Medium gray, fine-grained, angular to subangular quartz ss, w/5% black chert grains and 1% pyrite. (lower Lakota Fm.)
190 - 200	SANDSTONE	As above, very fine-grained. (lower Lakota Fm.)
200 - 210	SANDSTONE	As above. (lower Lakota Fm.)
	Morrison Formation - Top 210 feet.	
210 - 220	CLAYSTONE	V. dk gray, shaley claystone with disseminated

Sample Depth Interval (feet BGL)	Lithology	Description
		pyrite. (Morrison Fm).
220 - 230	CLAYSTONE	V. dk gray, firm, claystone w/10% lt gray clay. (Morrison Fm).
230 - 240	CLAYSTONE	V. dk gray, hard with 20% white quartz sis and vfs. (Morrison Fm).
240 - 250	CLAYSTONE	V. dk. gray, hard, with 30% very fine-grained, hard, gray siltstone. (Morrison Fm.)
250 - 260	SILTSTONE	Dk. gray, quartzose siltstone, mostly loose silt in sample. (Morrison Fm.)
260 – 270	SANDSTONE	Dk reddish-brown lithic ss w/rounded f-m sand about 30% of sample, 40% hard light to dark greenish-gray siltstone, 20% hard claystone, 10% gray clay. (Morrison Fm.)
270 - 280	MUDSTONE	Grayish-black, dk. reddish-brown and greenish-gray mudstone with 10% gray siltstone, 10% gray clay. (Morrison Fm.)
280 - 290	MUDSTONE	Greenish-gray, silty, hard. (Morrison Fm.)
290 - 300	LIMESTONE	Black to dk. grayish-black, mxtln, highly effervescent. (Morrison Fm.)
300 - 310	LIMESTONE	As above. (Morrison Fm.)
Redwater Shale Member of Sundance Formation - Top 307 feet		
310 – 320	SANDSTONE	Lt greenish gray, vf – f, subrnd to subang ~3% mafic clasts. (Redwater sh member Sundance Fm.)
320 – 330	SILTSTONE	Lt to med gray, locally sandy. (Redwater sh member Sundance Fm.)
330 – 340	CLAYSTONE	Greenish gray, silty, soft. (Redwater sh member Sundance Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
340 – 350	SHALE	Med gray, silty, soft. (Redwater sh member Sundance Fm.)
350 - 360	SHALE	Med gray, silty, interbeded hard and soft. (Redwater sh member Sundance Fm.)
360 - 370	SHALE	As above. (Redwater sh member Sundance Fm.)
370 - 380	SHALE	As above. (Redwater sh member Sundance Fm.)
380 - 390	SHALE	As above – softer. (Redwater sh member Sundance Fm.)
390 - 400	SILTSTONE	Med gray, hard with interbedded soft mudstone (Redwater sh member Sundance Fm.)
400 - 410	SHALE	Med gray, silty, interbeded hard and soft. (Redwater sh member Sundance Fm.)
410 - 420	SHALE	As above. (Redwater sh member Sundance Fm.)
420 - 430	SHALE	As above. (Redwater sh member Sundance Fm.)
430 - 440	SHALE	As above. (Redwater sh member Sundance Fm.)
440 - 450	CLAYSTONE	Med gray, slightly silty, returns as competent chips and remolded masses. (Redwater sh member Sundance Fm.)
450 - 460	CLAYSTONE	As above. (Redwater sh member Sundance Fm.)
460 - 470	CLAYSTONE	As above. (Redwater sh member Sundance Fm.)
470 - 480	CLAYSTONE	As above. (Redwater sh member Sundance Fm.)
480 - 490	CLAYSTONE	As above. (Redwater sh member Sundance Fm.)
490 - 500	SHALE	Med gray, silty, interbeded hard and soft. (Redwater sh member Sundance Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
500 - 510	SHALE	As above. (Redwater sh member Sundance Fm.)
510 - 520	CLAYSTONE	Med gray, soft, silty, Abundant Pyrite. (Redwater sh member Sundance Fm.)
520 - 530	CLAYSTONE	Med gray, soft, sandy, No Pyrite. (Redwater sh member Sundance Fm.)
530 - 540	CLAYSTONE	Light greenish gray, soft, silty. (Redwater sh member Sundance Fm.)
540 - 550	CLAYSTONE	Greenish white, soft, with 10-20% vf ss interbeds. (Redwater sh member Sundance Fm.)
550 - 560	MUDSTONE	Brown, interbedded with thin brown sis. (Redwater sh member Sundance Fm.)
560 - 570	SANDSTONE	Light greenish gray, vf, interbedded with minor sis and soft white claystone. (Redwater sh member Sundance Fm.)
570 - 580	MUDSTONE	Brown, interbedded with thin brown sis. (Redwater sh member Sundance Fm.)
LAK Member of Sundance Formation - Top 585 feet		
580 - 590	SANDSTONE	Light greenish gray and pinkish gray, vf, interbedded with minor sis and soft white claystone. (LAK member Sundance Fm.)
590 - 600	SANDSTONE	Light greenish gray, vf, interbedded with minor sis and soft white claystone. (LAK member Sundance Fm.)
600 - 610	SANDSTONE	As above. (LAK member Sundance Fm.)
610 - 620	SANDSTONE	Greenish White, vf, interbedded with minor sis and soft white claystone. (LAK member Sundance Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
620 – 630	SANDSTONE	Lt to med gray, vf, interbedded with minor sis and trace of soft white claystone. (LAK member Sundance Fm.)
630 - 640	SANDSTONE	As above. (LAK member Sundance Fm.)
Hulett Sandstone Member of Sundance Formation - Top 640 feet		
640 - 650	CLAYSTONE	Med gray, silty,with occasional ms interbeds. (Hulett ss mbr Sundance Fm)
650 - 660	CLAYSTONE	As above. (Hulett ss mbr Sundance Fm)
660 - 670	SANDSTONE	Lt to med gray, vf, interbedded with minor sis and trace of soft white claystone. (Hulett ss mbr Sundance Fm)
670 - 680	SANDSTONE	As above. (Hulett ss mbr Sundance Fm)
680 - 690	SANDSTONE	As above. (Hulett ss mbr Sundance Fm)
690 - 700	SANDSTONE	Lt to medray, vf, interbedded with soft white cs and trace of sis. (Hulett ss mbr Sundance Fm)
700 - 710	SANDSTONE	Lt to med gray, vf, interbedded with minor sis and trace of soft white claystone. (Hulett ss mbr Sundance Fm)
Stockade Beaver Shale Member of Sundance Formation - Top 710 feet		
710 - 720	SHALE	Med gray, soft interbedded with hard sis. (Stockade Beaver sh mbr Sundance Fm)
720 - 730	CLAYSTONE	Med gray, silty. (Stockade Beaver sh mbr Sundance Fm)
730 - 740	SHALE	Med gray, soft interbedded with soft cs. (Stockade Beaver sh mbr Sundance Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
740 - 750	SHALE	As above. (Stockade Beaver sh mbr Sundance Fm)
750 - 760	SHALE	As above. (Stockade Beaver sh mbr Sundance Fm)
760 - 770	SHALE	As above. (Stockade Beaver sh mbr Sundance Fm)
	Spearfish Formation - Top 770 feet	
770 - 780	MUDSTONE	Reddish brown to maroon thinly laminated with gypsum and interbeds. (Spearfish Fm)
780 - 790	SILTSTONE MUDSTONE	Reddish brown grading between ms and sis. Occasional med gray ms interbeds. (Spearfish Fm)
790 - 800	SILTSTONE	Reddish brown weak with ms interbeds – 80/20 sis to ms. (Spearfish Fm)
800 - 810	SILTSTONE	As above. (Spearfish Fm)
810 - 820	SILTSTONE	As above. (Spearfish Fm)
820 - 830	MUDSTONE	Reddish brown to maroon thinly laminated with gypsum and interbeds. (Spearfish Fm)
830 - 840	SILTSTONE	Reddish brown, hard, minor interbedded ms. (Spearfish Fm)
840 - 850	MUDSTONE	Dk red, silty. Weakly calcareous (Spearfish Fm.)
850 - 860	MUDSTONE	As above. (Spearfish Fm)
860 - 870	SILTSTONE	Reddish brown, hard, minor interbedded ms. (Spearfish Fm)
870 - 880	CLAYSTONE	Dk red, silty with thin, hard sis laminations. weakly calcareous (Spearfish Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
880 - 890	MUDSTONE	Reddish brown to maroon thinly laminated with gypsum and cs interbeds. (Spearfish Fm)
890 - 900	CLAYSTONE MUDSTONE	Reddish brown grading between ms and cs. Occasional med gray ms interbeds. (Spearfish Fm)
900 - 910	CLAYSTONE MUDSTONE	As above. (Spearfish Fm)
910 - 920	CLAYSTONE MUDSTONE	As above. (Spearfish Fm)
920 - 930	MUDSTONE	Reddish brown to maroon thinly laminated with minor gypsum and med gray cs interbeds. (Spearfish Fm)
930 - 940	MUDSTONE	As above. (Spearfish Fm)
940 - 950	MUDSTONE	As above. (Spearfish Fm)
950 - 960	MUDSTONE	As above. (Spearfish Fm)
960 - 970	MUDSTONE	As above. (Spearfish Fm)
970 - 980	MUDSTONE	As above. (Spearfish Fm)
980 - 990	MUDSTONE	As above. (Spearfish Fm)
990 - 1000	MUDSTONE	As above. (Spearfish Fm)
1000 - 1010	CLAYSTONE	Reddish brown, minor thin ms and sis interbeds, common gypsum on partings and as pore fillings. (Spearfish Fm)
1010 - 1020	CLAYSTONE	As above. (Spearfish Fm)
1020 - 1030	CLAYSTONE	Reddish brown interbedded with thin ms beds, minor gypsum. (Spearfish Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
1030 - 1040	CLAYSTONE	As above. (Spearfish Fm)
1040 - 1050	GYPSUM & CLAYSTONE	White gypsum and reddish brown claystone, interbeddd in equal amounts. (Spearfish Fm)
1050 - 1060	CLAYSTONE	Reddish brown claystone and white gypsum, 70/30 ms to gypsum. (Spearfish Fm)
1060 - 1070	SILTSTONE	Reddish brown, hard, minor interbedded ms. (Spearfish Fm)
1070 - 1080	MUDSTONE	Reddish brown to maroon thinly laminated with minor gypsum and med gray cs interbeds. (Spearfish Fm)
1080 - 1090	MUDSTONE	As above. (Spearfish Fm)
1090 - 1100	MUDSTONE	As above. (Spearfish Fm)
1100 - 1110	MUDSTONE	As above. (Spearfish Fm)
1110 - 1120	MUDSTONE	As above. (Spearfish Fm)
1120 - 1130	MUDSTONE	As above. (Spearfish Fm)
1130 - 1140	MUDSTONE	As above. (Spearfish Fm)
1140 - 1150	MUDSTONE	As above. (Spearfish Fm)
1150 - 1160	MUDSTONE	As above. (Spearfish Fm)
1160 - 1170	CLAYSTONE	Reddish brown cs and white gypsum, 70/30 ms to gypsum. Minor ms interbeds. (Spearfish Fm)
1170 - 1180	MUDSTONE	Reddish brown ms interbedded with cs and gypsum – 80/20 ms to cs & gyp. (Spearfish Fm)
1180 - 1190	CLAYSTONE	Reddish brown cs and white gypsum, 70/30 ms to gypsum. Minor ms interbeds. (Spearfish Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
1190 - 1200	CLAYSTONE	As above. (Spearfish Fm)
1200 - 1210	SILTSTONE	Reddish brown, hard, interbedded cs. 70/30 sis to cs. (Spearfish Fm)
1210 - 1220	SILTSTONE	Reddish brown, hard. (Spearfish Fm)
1220 - 1230	SILTSTONE	Reddish brown, hard, thinly laminated. With 10% dk gray cs and 15% white anhydrite. (Spearfish Fm)
1230 - 1240	MUDSTONE	Reddish brown, soft, fissile With 10% dk gray cs and 15% white anhydrite. (Spearfish Fm)
1240 - 1250	CLAYSTONE	Reddish brown, soft, With 10% dk gray cs and 15% white anhydrite. (Spearfish Fm)
1250 - 1260	ANHYDRITE	White, opaque to translucent, hard with minor med gray cs. (Spearfish Fm)
1260 -1270	ANHYDRITE	As above. (Spearfish Fm)
1270 - 1280	CLAYSTONE	Reddish brown, very soft. (Spearfish Fm)
1280 - 1290	ANHYDRITE	White, opaque to translucent, hard with minor med gray cs. (Spearfish Fm)
1290 - 1300	CLAYSTONE	Reddish brown, very soft. (Spearfish Fm)
1300 - 1310	CLAYSTONE	Reddish brown, soft, With 20% white anhydrite and minor med gray cs. (Spearfish Fm)
1310 - 1320	CLAYSTONE	Reddish brown, hard, with minor reddish brown ms interbeds. (Spearfish Fm)
1320 - 1330	CLAYSTONE	Reddish brown, hard,massive. (Spearfish Fm)
1330 - 1340	CLAYSTONE	Reddish brown, soft. (Spearfish Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
1340 - 1350	CLAYSTONE	Reddish brown, soft. (Spearfish Fm)
1350 - 1360	SILTSTONE	Reddish brown, hard, minor cs interbeds. (Spearfish Fm)
1360 - 1370	SILTSTONE	As above. (Spearfish Fm)
1370 - 1380	CLAYSTONE MUDSTONE	Reddish brown, interbedded soft cs and med hard ms, occasional thin sis. (Spearfish Fm)
1380 - 1390	CLAYSTONE MUDSTONE	As above. (Spearfish Fm)
1390 - 1400	CLAYSTONE MUDSTONE	As above. (Spearfish Fm)
1400 - 1410	ANHYDRITE	White to lt brown, massive, opaque, microxstln, interbedded with soft white gypsum. (Spearfish Fm).
Minnekahta Limestone Formation - Top 1410 feet		
1410 - 1420	LIMESTONE	Gy-bn, micritic, sandy with secondary euhedral dolomite crystallization. Abundant oil staining and seepage from pores and fractures. (Minnekahta Fm.)
1420 - 1430	LIMESTONE	Tan to brown, micritic, silty, minor oil (probably from above interval). (Minnekahta Fm.)
Opeche Shale Formation - Top 1430 feet		
1430 - 1440	MUDSTONE	Lt green, very silty, slightly calcareous (Opeche Fm)
1440 - 1450	MUDSTONE	Reddish brown, very silty, slightly calcareous (Opeche Fm)
1450 - 1460	SILTSTONE CLAYSTONE	Lt green to lt tan sis with lt tan claystone. (Opeche Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
1460 - 1470	CLAYSTONE	Lt green and tan, moderately hard, massive. (Opeche Fm)
		Minnelusa Formation Top 1470 feet
1470 - 1480	SILTSTONE	White to tan and minor white vf ss, moderately well indurated. Sis has oil stanning along fracture faces, ss has abundant oil in the pores. (Minnelusa Fm)
1480 - 1490	SANDSTONE	Med gray, f to med grained, subrnd to angular, moderately well indurated. Up to 10% coarse, angular qtz grains seen in some chips. Abundant oil in the pores. (Minnelusa Fm)
1490 - 1500	SANDSTONE	Lt brown, vf to med grained, quartzose with minor mafic accessory minerals, clay matrix, slightly to moderately calcareous, soft and friable. (Minnelusa Fm)
1500 - 1510	SANDSTONE	As above, but tan. (Minnelusa Fm)
1510 - 1520	SANDSTONE	As above, but tan. (Minnelusa Fm)
1520 - 1530	SANDSTONE	As above, but tan. (Minnelusa Fm)
1530 - 1540	CLAYSTONE	Lt gray, very soft(Minnelusa Fm)
1540 - 1550	SANDSTONE	Lt-Med gray, vf-fine grained, subround, mod to well sorted, quartzose, friable, firm, moderately, calcareous, oil staining (Minnelusa Fm)
1550 - 1560	ANHYDRITE	White to lt gray, finely crystalline, platy to massive, (Minnelusa Fm.)
1560 - 1570	ANHYDRITE	White to rose, finely crystalline, platy to massive, (Minnelusa Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
1570 - 1580	ANHYDRITE	White to lt gray to rose, finely crystalline, platy to massive, (Minnelusa Fm.)
1580 - 1590	SANDSTONE	Lt-Med gray, vf-fine grained, subround, mod to well sorted, quartzose, friable, firm, moderately, calcareous, oil staining (Minnelusa Fm)
1590 - 1600	SANDSTONE	As above (Minnelusa Fm)
1600 - 1610	DOLOMITE	Tan to lt. gray, sparry, finely crystalline, sugary texture, abundant disseminated pyrite, oil staining on fracture faces.
1620 - 1630	DOLOMITE	As above (Minnelusa Fm)
1630 - 1640	SANDSTONE	Lt-Med gray, quartzose, vf-fine grained, well sorted, subround, mod calcareous (cal or dolo cement), interstitial oil (Minnelusa Fm)
1640 - 1650	SANDSTONE	As above (Minnelusa Fm)
1650 - 1660	SANDSTONE	Black, quartzose, vf-fine grained, well sorted, mod calcareous, interstitial oil. (Minnelusa Fm)
1660 - 1670	SANDSTONE	Lt-Med gray, quartzose, vf-fine grained, well sorted, subround, mod calcareous (cal or dolo cement), interstitial oil. (Minnelusa Fm)
1670 - 1680	DOLOMITE	Lt grey to tan, sparry, fine crystalline structure, abundant disseminated pyrite, occ. Green accessory mineral (fluorite?) Fracture fill is sparry dolomite comprised of large rhombehedral crystals containing abundant twinning and laminae. (Minnelusa Fm)
1680 - 1690	DOLOMITE	Lt grey to tan, sparry, fine crystalline structure, abundant disseminated pyrite, occ. green accessory mineral (fluorite?). (Minnelusa Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
1690 - 1700	SANDSTONE	Lt gray, vf-fine grained, clay cement, v. soft, friable. (Minnelusa Fm)
1700 - 1710	SANDSTONE	Lt-Med gray, quartzose, vf-fine grained, well sorted, subround, mod calcareous (cal or dolo cement), interstitial oil. (Minnelusa Fm)
1710 - 1720	SANDSTONE	Med-Dark gray to Black, quartzose, vf-fine grained, well sorted, subround, mod calcareous (cal or dolo cement), interstitial oil. (Minnelusa Fm)
1720 - 1730	SANDSTONE	As above. (Minnelusa Fm)
1730 - 1740	SANDSTONE	As above. (Minnelusa Fm)
1740 - 1750	SANDSTONE	As above. (Minnelusa Fm)
1750 - 1760	SANDSTONE	As above. (Minnelusa Fm)
1760 - 1770	SANDSTONE	As above. (Minnelusa Fm)
1770 - 1780	SANDSTONE	As above. (Minnelusa Fm)
1780 - 1790	SANDSTONE	Dk gray to black, quartzose, vfine to fine grained, well sorted, friable, soft, weak calc cement, interstitial oil. abundant oil, hydrocarbon smell. (Minnelusa Fm)
1790 - 1800	SANDSTONE	As above. (Minnelusa Fm)
1800 - 1810	SANDSTONE	White to lt. gray, quartzose, vfine grained, well sorted, weak calk cement with interbedded SILTSTONE white to lt gray, firm. (Minnelusa Fm)
1810 - 1820	SANDSTONE	Lt-Med gray, quartzose, vf-fine grained, well sorted, subround, mod calcareous calc cement. (Minnelusa Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
1820 - 1830	SANDSTONE	Dk gray to black, quartzose, vfine to fine grained, well sorted, friable, soft, weak calc cement. (Minnelusa Fm)
1830 - 1840	SANDSTONE	White to lt. gray, quartzose, vfine-med grained grained, mod sorted, weak calc cement, Interstitial oil. (Minnelusa Fm)
1840 - 1850	SANDSTONE	Lt-Med gray, quartzose, vf-fine grained, well sorted, subround, mod calcareous calc cement, disseminated pyrite, interstitial oil. (Minnelusa Fm)
1850 - 1860	SANDSTONE	Sandstone as above with interbedded SILTSTONE white to lt gray, firm-hard, disseminated pyrite, oil staining on fracture faces. (Minnelusa Fm)
1860 - 1870	SANDSTONE	Sandstone as above with interbedded SILTSTONE greenish gray, firm-hard, abundant disseminated pyrite, oil staining on fracture faces. (Minnelusa Fm)
1870 - 1880	SANDSTONE	Lt grnish gray, vf grained. Qtzose with 20-30% white claystone and minor anhydrite. Abundant pyrite throughout. (Minnelusa Fm)
1880 - 1890	SANDSTONE	Med gray, vf, rounded, disseminated pyrite, oil staining. (Minnelusa Fm)
1890 - 1900	SANDSTONE	Dk gray to black, vf, angular to sub-rnd carbonaceous partings, thinly laminated. (Minnelusa Fm)
1900 - 1910	SANDSTONE	Lt tan to white, vf to f, sub rnd, qtzose with anhydrite matrix. (Minnelusa Fm)
1910 - 1920	CLAYSTONE	Green, soft cs with minor ss interbeds, abund pyrite. (Minnelusa Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
1920 - 1930	DOLOMITE	Med brownish gray, micrite. (Minnelusa Fm)
1930 - 1940	DOLOMITE	Lt brown, micrite, sandy in part. (Minnelusa Fm)
1940 - 1950	DOLOMITE	As above. (Minnelusa Fm)
1950 - 1960	DOLOMITE	Lt tan, occasional calcite secondary recrystallization, some very sandy beds. (Minnelusa Fm)
1960 - 1970	CLAYSTONE	Lt green and rose, very soft and sticky. (Minnelusa Fm)
1970 - 1980	CLAYSTONE	Lt green and dark red interbedded. Samples return as swirled, remolded masses. (Minnelusa Fm)
1980 - 1990	DOLOMITE	Lt green to lt tan, micrite. (Minnelusa Fm)
1990 - 2000	CLAYSTONE	Dk red, with minor thinly laminated dk red ms. (Minnelusa Fm)
2000 - 2010	CLAYSTONE	As above. (Minnelusa Fm)
2010 - 2020	SANDSTONE	Med gray to maroon vf to fine, sub ang to subrnd with 3-5% dark lithics. (Minnelusa Fm)
2020 - 2030	DOLOMITE	White, hard, micrite. (Minnelusa Fm)
2030 - 2040	DOLOMITE	Tan to white to purple predom micrite, occasional sparite (5-10%) and 20-30% lt green and dk red claystone. (Minnelusa Fm)
2040 - 2050	ANHYDRITE	Lt yellow, rose and transparent with abundant white chert and occasional euhedral calcite crystals (probable vein filling). (Minnelusa Fm)
2050 - 2060	DOLOMITE	Lt yellow, hard, sparite, highly recrystallized, occasionally vuggy. (Minnelusa Fm)
2060 - 2070	MUDSTONE	Dk red, clay rich (Minnelusa Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
2070 - 2080	DOLOMITE	Lt tan, micrite, (Minnelusa Fm)
2080 - 2090	SILTSTONE	Lt green to maroon, abund pyrite. (Minnelusa Fm)
2090 - 2100	LIMESTONE	Lt tan micrite with occasional coarsely crystalline vein fillings and minor maroon ms interbeds. (Minnelusa Fm)
2100 - 2110	DOLOMITE	Lt brown to brwnish gray, micritic, minor maroon mudstone. (Minnelusa Fm)
2110 - 2120	DOLOMITE	Lt green to brown and 10-20% maroon limestone both micritic. (Minnelusa Fm)
2120 - 2130	DOLOMITE	As above. (Minnelusa Fm)
2130 - 2140	DOLOMITE	Lt gray/green to brown, sucrose texture, crystalline vug/frac fillings. (Minnelusa Fm)
2140 - 2150	DOLOMITE	White/yellow to lt gray, sparry, abundant solution cavities, some red hematite staining. (Minnelusa Fm)
2150 - 2160	DOLOMITE	As above (Minnelusa Fm)
2160 - 2170	SANDSTONE	Red, v. fine to coarse grained, v. poorly sorted, clay matrix supported. (Minnelusa Fm)
2170 - 2180	SANDSTONE	As above (Minnelusa Fm)
2180 - 2190	SANDSTONE	As above (Minnelusa Fm)
2190 - 2200	SANDSTONE	White, quartz arenite, vf-fine grained, mod-well sorted, subang-subround, strong dolomite cement, non-calcareous. (Minnelusa Fm)
2200 - 2210	SANDSTONE	As above (Minnelusa Fm)
2210 - 2220	SANDSTONE	As above (Minnelusa Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
2220 - 2225	SILTSTONE	Maroon, hard, block, sl. calcareous (Minnelusa Fm)
2225 - 2230	SANDSTONE	White to lt. tan, to red, quartz arenite, v. fine to med grained, mod. Sorted, subang-subround, dolomite cement (Minnelusa Fm)
2230 - 2235	SANDSTONE	As above (Minnelusa Fm)
2235 - 2240	MUDSTONE	Red, blocky, firm to hard, coarse rounded quartz grains in matrix (Minnelusa Fm)
2240 - 2245	DOLOMITE	White to lt. gray, sparry with fine sucrose texture. Minor solution cavities. (Minnelusa Fm)
2245 - 2250	DOLOMITE	As above (Minnelusa Fm)
2250 - 2255	DOLOMITE	As above (Minnelusa Fm)
2255 - 2260	LIMESTONE	White to lt. gray, sparry, black to orange oxidized crystals (goethite). (Minnelusa Fm)
2260 - 2265	LIMESTONE	As above (Minnelusa Fm)
2265 - 2270	SANDSTONE	Red, brecciated, fine to coarse, poorly sorted, abundant calc frac fil. (Minnelusa Fm)
2270 - 2275	LIMESTONE	White to lt. brown, sparry (Minnelusa Fm)
2275 - 2280	DOLOMITE	Tan to red, sparry, fine sucrose texture, abundant calc frac fill, some solution cavities. (Minnelusa Fm)
2280 - 2285	LIMESTONE	White to light brown, sparry (Minnelusa Fm)
2285 - 2290	LIMESTONE	As above (Minnelusa Fm)
2290 - 2295	DOLOMITE	White, oolitic, with clear calcite cement (Minnelusa Fm)

Sample Depth Interval (feet BGL)	Lithology	Description
2295 - 2300	DOLOMITE	As above (Minnelusa Fm)
2300 - 2305	DOLOMITE	As above. (Minnelusa Fm)
2305 - 2310	DOLOMITE	As above (Minnelusa Fm)
2310 - 2315	DOLOMITE	As above (Minnelusa Fm)
2315 - 2320	SAND	Lt. tan, yellow/brown, v. fine sand to silt, angular, v. calcareous, looks like loess (Erosion Surface Deposit)
2320 - 2325	SAND	Lt. tan, very fine sand to silt, angular, 70% lithic fragments of limestone (Erosion Surface Deposit)
2325 - 2330	SILT	Lt. Tan, angular (Erosion Surface Deposit)
2330 - 2335	SILT	As above (Erosion Surface Deposit)
2335 - 2340	SAND	DK Gray/brown, v. fine sand, slightly calcareous, quartzose, slightly cohesive with minor clay content. (Erosion Surface Deposit)
2340 - 2345	SAND	As above. (Erosion Surface Deposit)
2345 - 2350	SAND	As above. (Erosion Surface Deposit)

Madison Formation Top 2350 feet

2350 - 2355	LIMESTONE	White, greenish gray, sparry, with some dolomite, sparry to microcrystalline. (Madison Fm)
2355 - 2360	LIMESTONE	As above. (Madison Fm)
2360 - 2365	DOLOMITE	As above. (Madison Fm)
2365- 2370	DOLOMITE	As above. (Madison Fm)
2370- 2375	LIMESTONE	Lt. tan, sparry, blocky, with abundant calcite fracture

Sample Depth Interval (feet BGL)	Lithology	Description
		fillings. (Madison Fm)
2375- 2380	LIMESTONE	As above. (Madison Fm)
2380- 2385	LIMESTONE	As above. (Madison Fm)
2385- 2390	DOLOMITE	Lt tan to lt gray, sparry with calc frac fill. (Madison Fm)
2390- 2395	DOLOMITE	As above. (Madison Fm)
2395- 2400	DOLOMITE	Lt tan to white, sparry, hard, with a few interstitial openings providing porosity. (Madison Fm)
2400- 2405	DOLOMITE	As above. (Madison Fm)
2405- 2410	DOLOMITE	As above. (Madison Fm)
2410- 2415	DOLOMITE	Lt tan to white, sparry, very hard, v. weak acid reaction, no apparent porosity. (Madison Fm)
2415- 2420	DOLOMITE	As above (Madison Fm)
2420- 2425	DOLOMITE	As above (Madison Fm)
2425- 2430	DOLOMITE	Lt tan to white, occ. pink, sparry, hard, slight acid reaction, 10 to 20 percent porosity. (Madison Fm)
2430- 2435	DOLOMITE	As above (Madison Fm)
2435- 2440	DOLOMITE	As above (Madison Fm)
2440 - 2445	DOLOMITE	As above (Madison Fm)
2445 - 2446	DOLOMITE	As above with less evident porosity. Sample contains about 5% clear sparry calcite fragments from fracture or void fillings. (Madison Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
2446 - 2447	OPEN VOID	Bit penetrated a void from 2446 to2447 feet with 30-gpm increase in airlift yield. (Madison Fm.)
2247 - 2250	DOLOMITE	Lt tan to white, occ. pink, sparry, hard, slight acid reaction, 10 to 20 percent porosity. 5% clear, sparry calcite fragments from void filling. (Madison Fm.)
2250 - 2255	DOLOMITE	Lt tan to white, occ. pink, sparry, hard, slight acid reaction, low porosity. (Madison Fm)
2455 - 2460	DOLOMITE	As above. (Madison Fm.)
2460 - 2465	DOLOMITE	Lt tan to pink, 50% microcrystalline, 50% sparry dolomite. Microcrystalline dolomite lt gray to lt tan, very hard, with no apparent porosity. Sparry dolomite lt. tan to pink, with 10-15% visible porosity. (Madison Fm.)
2465- 2470	DOLOMITE	As above. (Madison Fm.)
2470 - 2475	DOLOMITE	As above. (Madison Fm.)
2475 - 2480	DOLOMITE	Lt tan to pink, sparry, 10-15% porosity with 5 to 10% clear, tabular to rhombehedral dolomite crystals with conchoidal breaks, apparently fracture filling, must crush to get acid reaction. (Madison Fm.)
2480 - 2485	DOLOMITE	Dolomite a/a with 15% microcrystalline dolomite, very hard, with no apparent porosity. (Madison Fm.)
2485 - 2490	DOLOMITE	As above with abundant clear, rhombohedral, dolomite crystals, with conchoidal breaks. (Madison Fm.)
2490 - 2495	DOLOMITE	Lt tan to pink, sparry, abundant interstitial porosity, very porous 25-30%, with apparent micro fractures, some clear dolomite fracture fill crystals as above (Madison Fm.)
2495 - 2500	DOLOMITE	As above with 15-20% porosity. (Madison Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
2500 - 2505	DOLOMITE	As above. (Madison Fm.)
2505 - 2510	DOLOMITE	Lt tan, pink, 50/50 split between microcrystalline and sparry dolomite. Microcrystalline dolomite very hard, lt gray to lt tan, no apparent porosity. Sparry dolomite lt. tan to pink, with abundant interstitial porosity. (Madison Fm.)
2510 - 2515	DOLOMITE	Lt tan to pink. Mainly microcrystalline, very hard with little apparent porosity. (Madison Fm.)
2515 - 2520	DOLOMITE	As above (Madison Fm.)
2520 - 2525	DOLOMITE	Lt tan to pink 50/50 microcrystalline/sparry dolomite. Sparry dolomite has 10-15% visible porosity and 1% red accessory mineral. (Madison Fm.)
2525 - 2530	DOLOMITE	Lt tan to pink, sparry dolomite, with 1% red accessory mineral, 20-30% visible porosity, Clear rhombehedral dolomite fracture fillings with conchoidal fractures; weak acid reaction when crushed (Madison Fm.)
2530 - 2535	DOLOMITE	Lt tan to white, oolitic dolomite; 10% white microxtln dolomite, 5% fragments clear calcite fracture filling, some with red banding, less than 1% observable porosity. (Madison Fm.)
2535 - 2540	DOLOMITE	Lt tan to white, oolitic dolomite, 10-15% porosity, 1-2% clear calcite fragments, trace white microxtln dolomite, some with red spots (specs of hematite). (Madison Fm.)
2540 - 2545	DOLOMITE	As above, nearly all oolitic or sparry, low porosity. (Madison Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
2545 - 2550	LIMESTONE	Brownish gray finely crystalline biosparite. Crinoids and shell fragment present in limestone. Less than 5% oolitic dolomite, low porosity. (Madison Fm.)
2550 - 2555	LIMESTONE	As above. (Madison Fm.)
2555 - 2560	LIMESTONE	As above. (Madison Fm.)
2560 - 2565	DOLOMITE	Lt tan occ pink, Sparry, 10-15% interstitial porosity (Madison Fm.)
2565 - 2570	DOLOMITE	As above with little to no visible porosity. (Madison Fm.)
2570 - 2575	DOLOMITE	Lt gray to lt tan, microcrystalline, very hard, little to no visible porosity. (Madison Fm.)
2575 - 2580	DOLOMITE	As above. (Madison Fm.)
2580 - 2585	DOLOMITE	Lt tan to white, occ pink, sparry, 1-2% red accessory mineral, 10-15% interstitial porosity, few clear dolomite fracture fill crystals, rhombehedral, conchoidal fractures. (Madison Fm.)
2585 - 2590	DOLOMITE	As above. (Madison Fm.)
2590 - 2595	DOLOMITE	Lt tan to lt gray, sparry, 20-30% interstitial porosity, abundant disseminated interstitial hematite and hematite pore filling. (Madison Fm.)
2595 - 2600	DOLOMITE	As above. (Madison Fm.)
2600 - 2605	LIMESTONE	Lt to dark gray, sparry, hematite staining, <5% visible porosity. (Madison Fm.)
2605 - 2610	LIMESTONE	As above. (Madison Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
2610 - 2615	LIMESTONE	As above. (Madison Fm.)
2615 - 2620	NO SAMPLE	No Sample
2620 - 2625	LIMESTONE	Lt tan to gray, sparry, orange chert grains, disseminated interstitial hematite. Little to no visible porosity. (Madison Fm.)
2625 - 2630	LIMESTONE	As above. (Madison Fm.)
2630 - 2635	DOLOMITE	Lt tan, sparry, 15-20% interstitial porosity, clear dolomite fracture fill. (Madison Fm.)
2635 - 2640	DOLOMITE	Lt tan to gray, sparry, 20-25% interstitial porosity, clear dolomite fracture fill, abnt disseminated pyrite. . (Madison Fm.)
2640 - 2645	DOLOMITE	As above. (Madison Fm.)
2645 - 2650	DOLOMITE	As above. (Madison Fm.)
2650 - 2655	DOLOMITE	Lt tan to gray, sparry, 5-10% porosity with interstitial hematite and pyrite. (Madison Fm.)
2655 - 2660	LIMESTONE	Red and gray. Red biosparite, contains brachiopod and crinoid fossils, abundant interstitial hematite. Gray micrite to finely microcrystalline. Little visible porosity (Madison Fm.)
2660 - 2665	LIMESTONE	Lt tan to gray sparite, 10% of sample is oolitic, apparent clear calcite fracture fillings and microfractures, Little visible porosity. (Madison Fm.)
2665 - 2670	DOLOMITE	Lt. brn to gray sparite. Lt tan is very finely xtln and white is medium xtln. 1-2% recrystallized, clear sparry dolomite and traces clear calcite fracture fillings. (Madison Fm.)

Sample Depth Interval (feet BGL)	Lithology	Description
2670 - 2675	DOLOMITE	Lt. brn to gray sparite, 10-15% white oolitic dolomite, traces dk brownish gray v. finely xtln dolo, traces pink dolomite, trace pyrit. (Madison Fm.)
2675 - 2680	DOLOMITE	Lt. brn to gray sparite, 15-20% whitish gray oolitic limestone, trace pyrite and iron oxide in coarsely xtln limestone. (Madison Fm.)
2680 - 2685	DOLOMITE	Lt. brn sparite with minor white, coarsely xtln sparite, all recrystallized dolomite with 10-12% porosity evident in 50% of cuttings. (Madison Fm.)
2685 - 2690	DOLOMITE	As above with 2-3% purple stained coarsely xtln dolomite, some very dark gray finely xtln dolomite. Bottom of this interval may penetrated Whitewood Dolomite. (Madison Fm.)

Whitewood Dolomite – Top 2690 feet

2690 - 2695	DOLOMITE	V dk gray, 50% dense, very finely xtln hard dolomite, with <1% dissem. Pyrite. 15% of sample lt. gray, coarsely xtln dolomite with iron stains and hematite pseudo-morphs after pyrite, remainder mostly dk gy bn xtln dolomite with 1-2% porosity. (Whitewood Dolomite)
2695 - 2700	DOLOMITE	Brown to white dolomite; brown dolomite very finely xtln, white dolomite is fine to medium xtln biomicrite. Some clear calcite coatings on some surfaces. (Whitewood Dolomite)

Sample Depth Interval (feet BGL)	Lithology	Description
2700 - 2705	DOLOMITE	Dk gray, mxtln dolomite with <1% pyrite is 30% of sample, remainder of sample evenly divided between brown finely xtln dolo and while dolomicrite, as above, with few pieces with pink color cast. (Whitewood Dolomite)
2705 - 2710	DOLOMITE	Brown finely xtln dolo. With 3-5% porosity, 10% white biomicrite. (Whitewood Dolomite)
2710 - 2715	DOLOMITE	As above. (Whitewood Dolomite)
2715 - 2720	DOLOMITE	As above, 50% brown finely xtln, 50% white biomicrite. (Whitewood Dolomite)
2720 - 2725	DOLOMITE	Lt tan to white, sparry, oolitic, with calcite martrix. 5-10% porosity. (Whitewood Dolomite)
2725 - 2730	LIMESTONE	Lt tan to brown, mxtln to finley xtln, 10-15% porosity (Whitewood Dolomite)
2730 - 2735	LIMESTONE	As above. (Whitewood Dolomite)
2735 - 2740	LIMESTONE	As above. (Whitewood Dolomite)
2740 - 2745	LIMESTONE	As above. (Whitewood Dolomite)
2745 - 2750	DOLOMITE	Lt tan to white, sparry, sucrose texture, disseminated hematite. (Whitewood Dolomite)
2750 - 2755	DOLOMITE	As above. (Whitewood Dolomite)
2755 - 2760	DOLOMITE	As above. (Whitewood Dolomite)
2760 - 2765	DOLOMITE	As above. (Whitewood Dolomite)
2765 - 2770	DOLOMITE	White, sparry, sucrose texture, disseminated hematite, 5% clear calcite frac fill crystals with traces of iron staining, 10-15% porosity. (Whitewood Dolomite)

Sample Depth Interval (feet BGL)	Lithology	Description
2770 - 2775	DOLOMITE	Lt brown, sparry, sucrose texture, clear calcite frac fill crystals, 10-15% porosity. (Whitewood Dolomite)
2775 - 2780	DOLOMITE	As above. (Whitewood Dolomite)
2780 - 2785	DOLOMITE	Lt brown to tan, mxtln to fine xtln, disseminated hematite, 5% clear calcite frac fill crystals with traces of iron staining, 5% porosity. (Whitewood Dolomite)
2785 - 2790	DOLOMITE	As above with small green siltstone, soft. (Whitewood Dolomite)

Winnipeg Formation – Top 2791 feet

2790 - 2795	DOLOMITE	As above with traces green siltstone. (Winnepeg Formation)
2795 - 2801	DOLOMITE	Lt brown to tan, mxtln to fine xtln, disseminated hematite, 5% clear calcite frac fill crystals with traces of iron staining, 5% porosity. (Winnipeg Formation)

Total Depth = 2801 feet