



COLORADO
**Division of Reclamation,
Mining and Safety**
Department of Natural Resources
1313 Sherman Street, Room 215
Denver, CO 80203

MEMORANDUM

Date: January 5, 2021

To: Patrick Lennberg; Division of Reclamation, Mining & Safety

From: Peter Hays; Division of Reclamation, Mining & Safety

Re: **Native/Pierre Mine; M-1977-321; Conversion Application (CN-01); Jesik Consulting Slope Stability Report; Geotechnical Review Memo**

The Division of Reclamation, Mining and Safety (Division/DRMS) reviewed the Slope Stability Report received from Jesik Consulting on December 28, 2020 for the Native/Pierre Mine permit conversion application (CN-01), File No. M-1977-321.

The Slope Stability Analysis was submitted to address any significant, valuable and permanent man-made structures within 200 feet of the affected lands, since the Operator was not able to obtain agreements with all structure owners as required by Rule 6.4.19.

In accordance with Table 1 - Recommended Factors of Safety for Slope Stability Analysis for Operations and Reclamation within Section 30.4 of the Policies of the Mined Land Reclamation Board (MLRB) effective May 16, 2018, the Division will require the Operator to comply with the factor of safety (FOS) of 1.5 for critical structures in static conditions since the Operator utilized generalized strength measurements in the analysis.

The Division replicated the Operator's slope stability analysis using Clover Technologies Galena Slope Stability Analysis System, Version 7.2 with the X-Left coordinate maintained at the edge of closest man-made structure. The Division did not replicate the shallow failure model analysis, since shallow failures would be repaired during the life of mine and are unlikely to cause damage to the nearby structures. A table of the Applicant's and the Division's analysis factor of safety (FOS) results for the deep failure models are below:

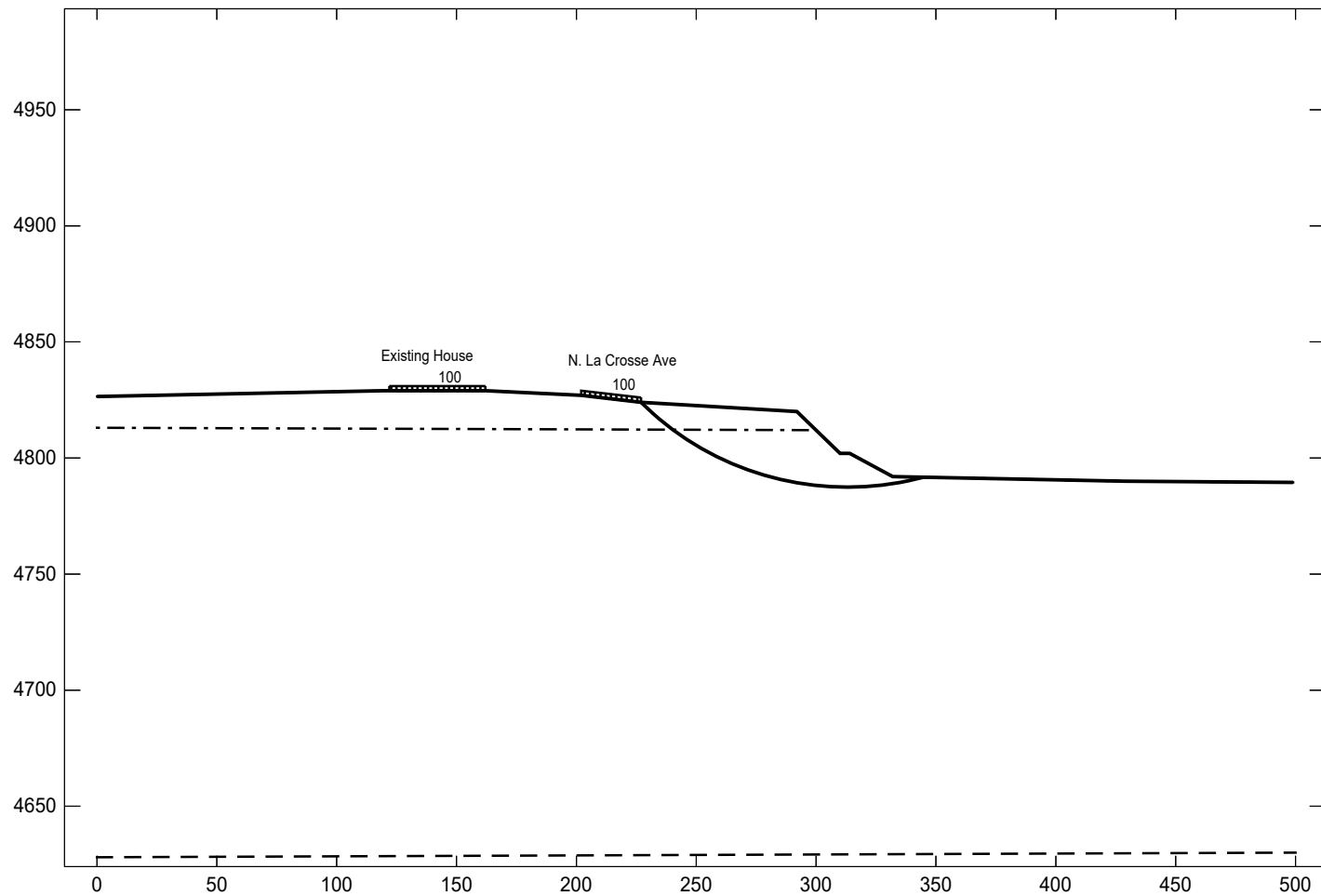


Analysis Name	Applicant's FOS	DRMS FOS
Existing Highwall – Deep Failure	2.82	2.98
Section B – Deep Failure	3.04	3.16
Section C – Deep Failure	3.46	5.13
Section D – Deep Failure	4.55	4.92
Section E – Deep Failure	3.49	2.62
Section F – Deep Failure	3.05	4.51

The Division accepts the Jesik Consulting slope stability analysis as an alternative to the Operator obtaining agreements with all structure owners within 200-feet of the affected lands.

If groundwater is intercepted and/or the soils differ from the expected profiles, the Operator must contact the Division immediately and reevaluate the slope stability analysis based on the updated information. Please note any transgression from the proposed slope geometries will be considered a violation if the conversion application is approved and issued by the Division. The Division's stability analysis model results are attached.

If you have any questions, please contact me at peter.hays@state.co.us or (303) 866-3567 Ext. 8124.



GALENA Version 7.2

Project Native/Pierre Mine
Existiing Highwall

File: G:\My Drive\1 - My Projects Google\8 Galena - Stability Analysis Models\NativePierre\Existing Highwall.gmf

Analysis 1

Single Stability Analysis
Method: Bishop Simplified
Surface: Circular

Results

Factor of Safety: 2.98

Edited: 5 Jan 2021 Processed: 5 Jan 2021

Dept of the Interior - Office of Surface Mining

Project: Native/Pierre Mine
 File: G:\My Drive\1 - My Projects Google\8 Galena - Stability Analysis Models\NativePierre\Existing Highwall.gmf
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DATA: Analysis 1 - Existing Highwall

Material Properties (2 materials)

Material: 1 (Mohr-Coulomb Isotropic) - Clay
 Cohesion 0.00 Phi 22.0 UnitWeight 105.00 Ru Auto
 Material: 2 (Mohr-Coulomb Isotropic) - Pierre Shale
 Cohesion 600.00 Phi 26.0 UnitWeight 122.00 Ru Auto

Water Properties

Unit weight of water: 62.400 Unit weight of water/medium above ground: 62.400

Material Profiles (2 profiles)

Profile: 1 (2 points) Material beneath: 1 - Clay
 0.00 4830.00 499.00 4830.00
 Profile: 2 (3 points) Material beneath: 2 - Pierre Shale
 0.00 4813.00 300.00 4812.00 499.00 4812.00

Slope Surface (12 points)

0.00	4826.50	120.00	4829.00	162.00	4829.00	202.00	4827.00	227.00	4824.00
292.00	4820.00	300.00	4812.00	310.00	4802.00	314.00	4802.00	332.00	4792.00
429.00	4790.00	499.00	4789.50						

Phreatic Surface (2 points)

0.00	4628.00	500.00	4630.00
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Failure Surface

Circular surface defined by: XL, XR, R

Intersects: XL:	227.00	YL:	4824.00	XR:	344.83	YR:	4791.74
Centre: XC:	313.14	YC:	4907.30	Radius: R:			119.83

Distributed Loads (2 loads)

Load	X-Left	Pressure	X-Right	Pressure
1	122.00	100.0	162.00	100.0
2	202.00	100.0	227.00	100.0

RESULTS: Analysis 1 - Existing Highwall

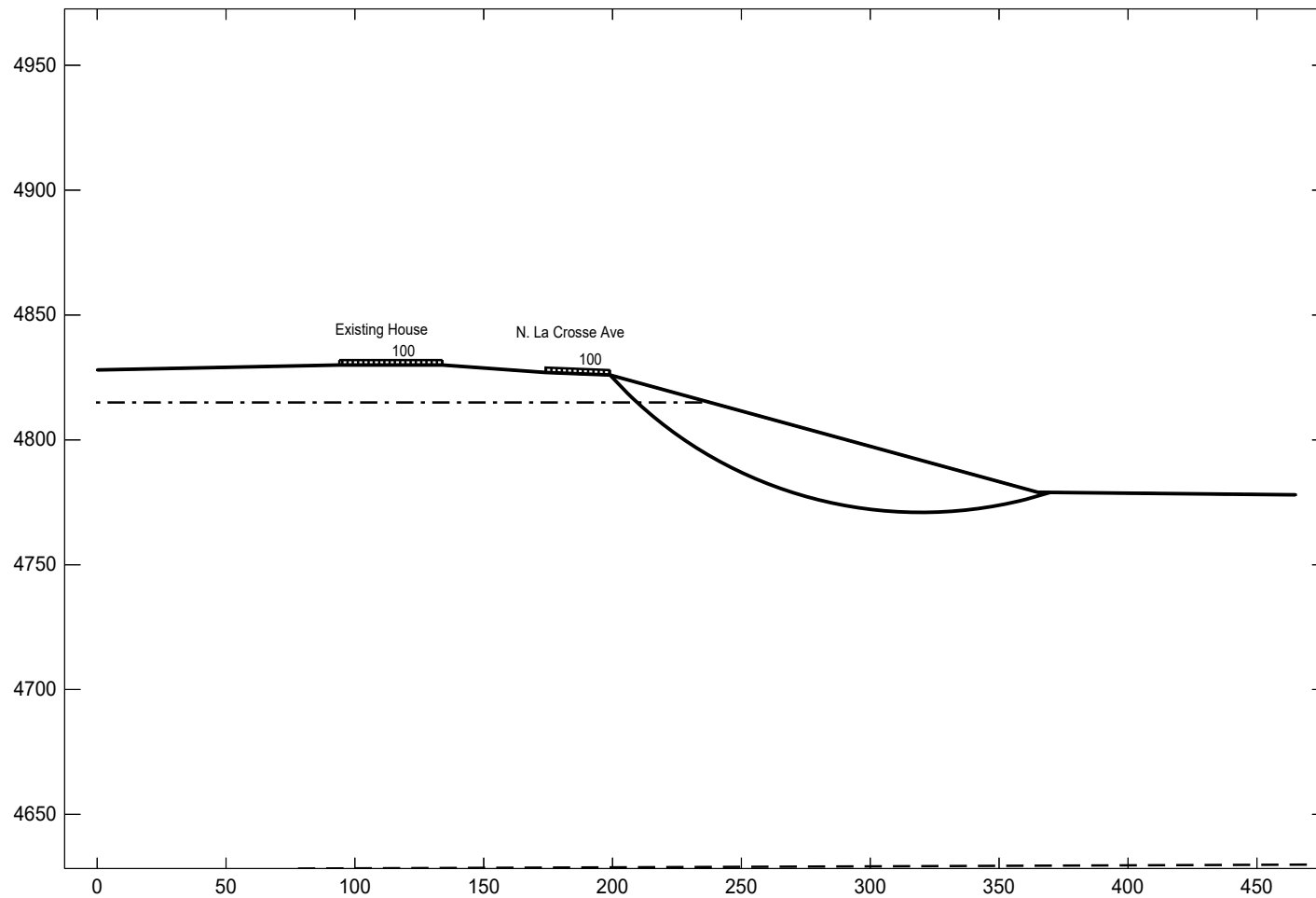
Bishop Simplified Method of Analysis - Circular Failure Surface

Factor of Safety: 2.98

Slice Geometry and Properties (42 slices)

Slice	X-Left	X-S Area	Angle	Width	Base Length	Matl	Cohesion	Phi	Weight	Porewater Force	Normal Stress	Test Factor
1	227.00	2.66	44.3	2.41	3.37	1	0.00	22.0	279.75	0.00	102.41	1.23
2	229.41	7.99	44.3	2.41	3.37	1	0.00	22.0	839.36	0.00	307.27	1.23
3	231.82	13.85	41.1	2.54	3.37	1	0.00	22.0	1454.00	0.00	511.70	1.19
4	234.37	19.09	41.1	2.54	3.37	1	0.00	22.0	2004.15	0.00	705.29	1.19
5	236.91	33.22	37.9	3.40	4.31	1	0.00	22.0	3488.15	0.00	927.24	1.15
6	240.31	22.41	37.9	1.92	2.43	2	600.00	26.0	2377.76	0.00	959.36	1.12
7	242.23	36.71	34.7	2.77	3.37	2	600.00	26.0	3969.80	0.00	1160.53	1.09
8	245.00	41.56	34.7	2.77	3.37	2	600.00	26.0	4568.90	0.00	1354.60	1.09
9	247.78	47.90	31.4	2.88	3.37	2	600.00	26.0	5332.30	0.00	1572.62	1.07
10	250.66	52.46	31.4	2.88	3.37	2	600.00	26.0	5896.09	0.00	1750.73	1.07
11	253.53	58.63	28.2	2.97	3.37	2	600.00	26.0	6641.27	0.00	1954.94	1.04
12	256.51	62.83	28.2	2.97	3.37	2	600.00	26.0	7161.89	0.00	2115.97	1.04
13	259.48	68.67	25.0	3.06	3.37	2	600.00	26.0	7869.79	0.00	2304.62	1.03
14	262.54	72.45	25.0	3.06	3.37	2	600.00	26.0	8340.46	0.00	2447.78	1.03
15	265.59	77.83	21.8	3.13	3.37	2	600.00	26.0	8994.23	0.00	2619.72	1.01
16	268.73	81.15	21.8	3.13	3.37	2	600.00	26.0	9408.13	0.00	2743.84	1.01
17	271.86	85.93	18.5	3.20	3.37	2	600.00	26.0	9991.87	0.00	2897.91	1.00
18	275.06	88.74	18.5	3.20	3.37	2	600.00	26.0	10343.66	0.00	3002.32	1.00
19	278.25	92.82	15.3	3.25	3.37	2	600.00	26.0	10843.55	0.00	3137.54	0.99
20	281.51	95.06	15.3	3.25	3.37	2	600.00	26.0	11128.36	0.00	3221.19	0.99
21	284.76	98.35	12.1	3.30	3.37	2	600.00	26.0	11533.23	0.00	3336.71	0.99
22	288.06	100.01	12.1	3.30	3.37	2	600.00	26.0	11746.53	0.00	3399.30	0.99
23	291.36	19.68	8.8	0.64	0.65	2	600.00	26.0	2313.05	0.00	3477.88	0.99
24	292.00	88.42	8.9	3.01	3.05	2	600.00	26.0	10455.94	0.00	3355.19	0.99
25	295.01	80.77	8.9	3.01	3.05	2	600.00	26.0	9675.79	0.00	3102.60	0.99
26	298.02	48.76	5.6	1.98	1.99	2	600.00	26.0	5915.52	0.00	2924.72	0.99
27	300.00	53.76	5.6	2.37	2.38	2	600.00	26.0	6558.42	0.00	2705.90	0.99
28	302.37	48.70	5.6	2.37	2.38	2	600.00	26.0	5941.67	0.00	2449.72	0.99
29	304.74	48.00	2.4	2.63	2.63	2	600.00	26.0	5856.00	0.00	2201.37	0.99
30	307.37	41.36	2.4	2.63	2.63	2	600.00	26.0	5046.53	0.00	1895.92	0.99
31	310.00	21.39	2.4	1.48	1.48	2	600.00	26.0	2609.43	0.00	1747.00	0.99
32	311.48	36.59	-0.8	2.52	2.52	2	600.00	26.0	4464.44	0.00	1776.10	1.00
33	314.00	29.30	-0.8	2.11	2.11	2	600.00	26.0	3574.74	0.00	1700.23	1.00
34	316.11	26.76	-0.8	2.11	2.11	2	600.00	26.0	3265.02	0.00	1553.27	1.00
35	318.22	37.09	-4.0	3.36	3.37	2	600.00	26.0	4525.03	0.00	1374.97	1.01
36	321.59	30.00	-4.0	3.36	3.37	2	600.00	26.0	3659.95	0.00	1114.86	1.01
37	324.95	22.49	-7.3	3.35	3.37	2	600.00	26.0	2743.25	0.00	863.54	1.03
38	328.30	14.84	-7.3	3.35	3.37	2	600.00	26.0	1810.23	0.00	578.75	1.03
39	331.64	9.15	-10.5	3.32	3.37	2	600.00	26.0	1116.49	0.00	385.57	1.05
40	334.96	6.89	-10.5	3.32	3.37	2	600.00	26.0	840.27	0.00	299.69	1.05
41	338.28	4.27	-13.7	3.28	3.37	2	600.00	26.0	520.40	0.00	216.61	1.07
42	341.55	1.42	-13.7	3.28	3.37	2	600.00	26.0	173.34	0.00	106.25	1.07

X-S Area: 1929.96 Path Length: 128.18 X-S Weight: 225278.72



GALENA Version 7.2

Project Native/Pierre Mine
Section B

File: G:\My Drive\1 - My Projects Google\8 Galena - Stability Analysis Models\NativePierre\Section B.gmf

Analysis 1

Single Stability Analysis
Method: Bishop Simplified
Surface: Circular

Results

Factor of Safety: 3.16

Edited: 5 Jan 2021 Processed: 5 Jan 2021

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Project: Native/Pierre Mine
 File: G:\My Drive\1 - My Projects Google\8 Galena - Stability Analysis Models\NativePierre\Section B.gmf
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DATA: Analysis 1 - Section B

Material Properties (2 materials)

Material: 1 (Mohr-Coulomb Isotropic) - Clay
 Cohesion 0.00 Phi 22.0 UnitWeight 105.00 Ru Auto
 Material: 2 (Mohr-Coulomb Isotropic) - Pierre Shale
 Cohesion 600.00 Phi 26.0 UnitWeight 122.00 Ru Auto

Water Properties

Unit weight of water: 62.400 Unit weight of water/medium above ground: 62.400

Material Profiles (2 profiles)

Profile: 1 (2 points) Material beneath: 1 - Clay
 0.00 4830.00 465.00 4830.00
 Profile: 2 (3 points) Material beneath: 2 - Pierre Shale
 0.00 4815.00 245.00 4815.00 465.00 4815.00

Slope Surface (7 points)

0.00	4828.00	94.00	4830.00	134.00	4830.00	174.00	4827.00	199.00	4826.00
365.00	4779.00	465.00	4778.00						

Phreatic Surface (2 points)

0.00	4628.00	500.00	4630.00
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Failure Surface

Circular surface defined by: XL, XR, R

Intersects: XL: 199.00 YL: 4826.00 XR: 369.75 YR: 4778.95
 Centre: XC: 319.77 YC: 4930.95 Radius: R: 160.00

Distributed Loads (2 loads)

Load	X-Left	Pressure	X-Right	Pressure
1	94.00	100.0	134.00	100.0
2	174.00	100.0	199.00	100.0

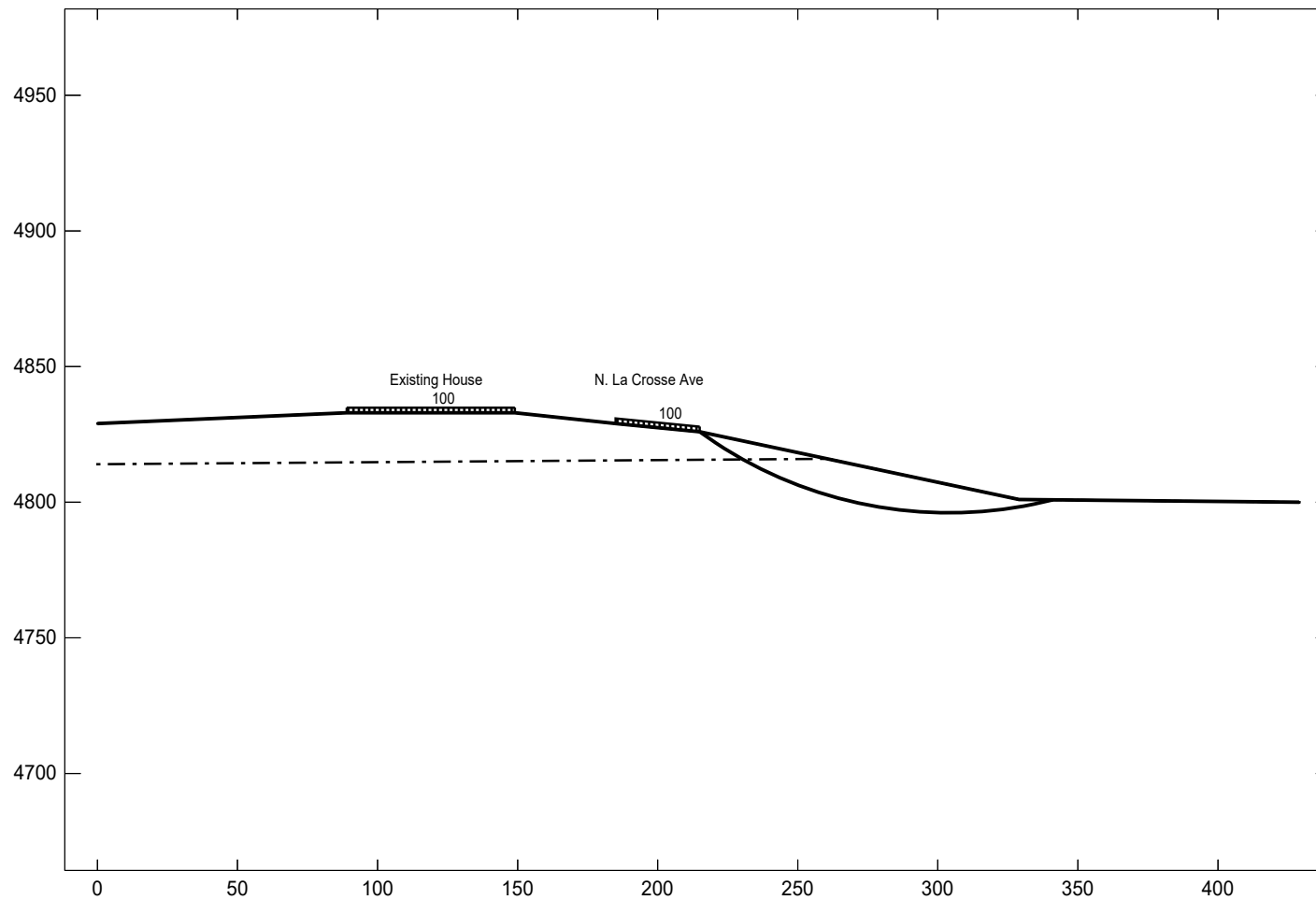
RESULTS: Analysis 1 - Section B

Bishop Simplified Method of Analysis - Circular Failure Surface

Factor of Safety: 3.16

Slice Geometry and Properties (39 slices)

Slice	X-Left	X-S Area	Angle	Width	Base Length	Matl	Cohesion	Phi	Weight	Porewater Force	Normal Stress	Test Factor
1	199.00	4.49	47.2	3.35	4.94	1	0.00	22.0	471.17	0.00	123.44	1.29
2	202.35	13.46	47.2	3.35	4.94	1	0.00	22.0	1413.51	0.00	370.33	1.29
3	205.71	26.17	43.7	3.92	5.42	1	0.00	22.0	2747.43	0.00	624.24	1.23
4	209.63	29.20	43.7	3.22	4.45	2	600.00	26.0	3150.64	0.00	694.68	1.21
5	212.85	42.32	40.2	3.77	4.94	2	600.00	26.0	4743.25	0.00	969.96	1.16
6	216.62	50.31	40.2	3.77	4.94	2	600.00	26.0	5786.32	0.00	1214.52	1.16
7	220.39	60.64	36.6	3.96	4.94	2	600.00	26.0	7103.25	0.00	1480.95	1.12
8	224.36	67.88	36.6	3.96	4.94	2	600.00	26.0	8061.13	0.00	1697.69	1.12
9	228.32	77.79	33.1	4.14	4.94	2	600.00	26.0	9341.38	0.00	1938.74	1.08
10	232.46	84.10	33.1	4.14	4.94	2	600.00	26.0	10193.45	0.00	2125.85	1.08
11	236.59	26.72	29.6	1.26	1.44	2	600.00	26.0	3256.23	0.00	2283.72	1.06
12	237.85	80.56	29.6	3.67	4.22	2	600.00	26.0	9828.67	0.00	2364.91	1.06
13	241.52	84.38	29.6	3.67	4.22	2	600.00	26.0	10294.44	0.00	2481.68	1.06
14	245.19	106.43	26.0	4.44	4.94	2	600.00	26.0	12984.69	0.00	2634.34	1.03
15	249.62	110.47	26.0	4.44	4.94	2	600.00	26.0	13477.22	0.00	2737.60	1.03
16	254.06	117.02	22.5	4.56	4.94	2	600.00	26.0	14276.58	0.00	2866.73	1.02
17	258.63	119.74	22.5	4.56	4.94	2	600.00	26.0	14608.76	0.00	2935.16	1.02
18	263.19	124.62	18.9	4.67	4.94	2	600.00	26.0	15203.81	0.00	3029.03	1.00
19	267.86	125.93	18.9	4.67	4.94	2	600.00	26.0	15363.52	0.00	3061.57	1.00
20	272.53	128.94	15.4	4.76	4.94	2	600.00	26.0	15730.44	0.00	3118.92	0.99
21	277.29	128.77	15.4	4.76	4.94	2	600.00	26.0	15709.83	0.00	3114.68	0.99
22	282.05	129.77	11.9	4.83	4.94	2	600.00	26.0	15832.00	0.00	3134.20	0.99
23	286.89	128.07	11.9	4.83	4.94	2	600.00	26.0	15624.14	0.00	3092.54	0.99
24	291.72	126.99	8.3	4.89	4.94	2	600.00	26.0	15492.52	0.00	3073.24	0.99
25	296.60	123.73	8.3	4.89	4.94	2	600.00	26.0	15094.62	0.00	2993.61	0.99
26	301.49	120.55	4.8	4.92	4.94	2	600.00	26.0	14706.84	0.00	2934.52	0.99
27	306.41	115.72	4.8	4.92	4.94	2	600.00	26.0	14118.27	0.00	2816.43	0.99
28	311.33	110.50	1.3	4.94	4.94	2	600.00	26.0	13480.50	0.00	2716.96	1.00
29	316.27	104.13	1.3	4.94	4.94	2	600.00	26.0	12703.37	0.00	2560.16	1.00
30	321.21	96.96	-2.3	4.93	4.94	2	600.00	26.0	11828.56	0.00	2419.59	1.01
31	326.14	89.09	-2.3	4.93	4.94	2	600.00	26.0	10868.88	0.00	2223.89	1.01
32	331.08	80.14	-5.8	4.91	4.94	2	600.00	26.0	9776.89	0.00	2041.50	1.02
33	335.99	70.84	-5.8	4.91	4.94	2	600.00	26.0	8643.09	0.00	1807.08	1.02
34	340.90	60.34	-9.4	4.87	4.94	2	600.00	26.0	7361.22	0.00	1582.28	1.04
35	345.78	49.70	-9.4	4.87	4.94	2	600.00	26.0	6063.47	0.00	1309.03	1.04
36	350.65	37.91	-12.9	4.81	4.94	2	600.00	26.0	4625.53	0.00	1041.20	1.06
37	355.46	26.05	-12.9	4.81	4.94	2	600.00	26.0	3178.22	0.00	729.53	1.06
38	360.28	13.29	-16.4	4.72	4.92	2	600.00	26.0	1621.28	0.00	418.36	1.09
39	365.00	3.44	-16.4	4.75	4.95	2	600.00	26.0	419.63	0.00	151.29	1.09
X-S Area:		3097.15	Path Length:		187.66	X-S Weight:		375184.75				



GALENA Version 7.2

Project Native/Pierre Mine
Section C

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Analysis 1

Single Stability Analysis
Method: Bishop Simplified
Surface: Circular

Results

Factor of Safety: 5.13

Edited: 5 Jan 2021 Processed: 5 Jan 2021

Dept of the Interior - Office of Surface Mining

Project: Native/Pierre Mine
 File: G:\My Drive\1 - My Projects Google\8 Galena - Stability Analysis Models\NativePierre\Section C.gmf
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DATA: Analysis 1 - Section C

Material Properties (2 materials)

Material: 1 (Mohr-Coulomb Isotropic) - Clay
 Cohesion 0.00 Phi 22.0 UnitWeight 105.00 Ru Auto
 Material: 2 (Mohr-Coulomb Isotropic) - Pierre Shale
 Cohesion 600.00 Phi 26.0 UnitWeight 122.00 Ru Auto

Water Properties

Unit weight of water: 62.400 Unit weight of water/medium above ground: 62.400

Material Profiles (2 profiles)

Profile: 1 (2 points) Material beneath: 1 - Clay
 0.00 4850.00 429.00 4850.00
 Profile: 2 (3 points) Material beneath: 2 - Pierre Shale
 0.00 4814.00 263.00 4816.00 429.00 4815.00

Slope Surface (7 points)

0.00	4829.00	89.00	4833.00	149.00	4833.00	185.00	4829.00	215.00	4826.00
329.00	4801.00	429.00	4800.00						

Phreatic Surface (2 points)

0.00	4628.00	500.00	4630.00
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Failure Surface

Circular surface defined by: XL, XR, R

Intersects: XL: 215.00 YL: 4826.00 XR: 341.08 YR: 4800.88
 Centre: XC: 303.98 YC: 4943.64 Radius: R: 147.50

Distributed Loads (2 loads)

Load	X-Left	Pressure	X-Right	Pressure
1	89.00	100.0	149.00	100.0
2	185.00	100.0	215.00	100.0

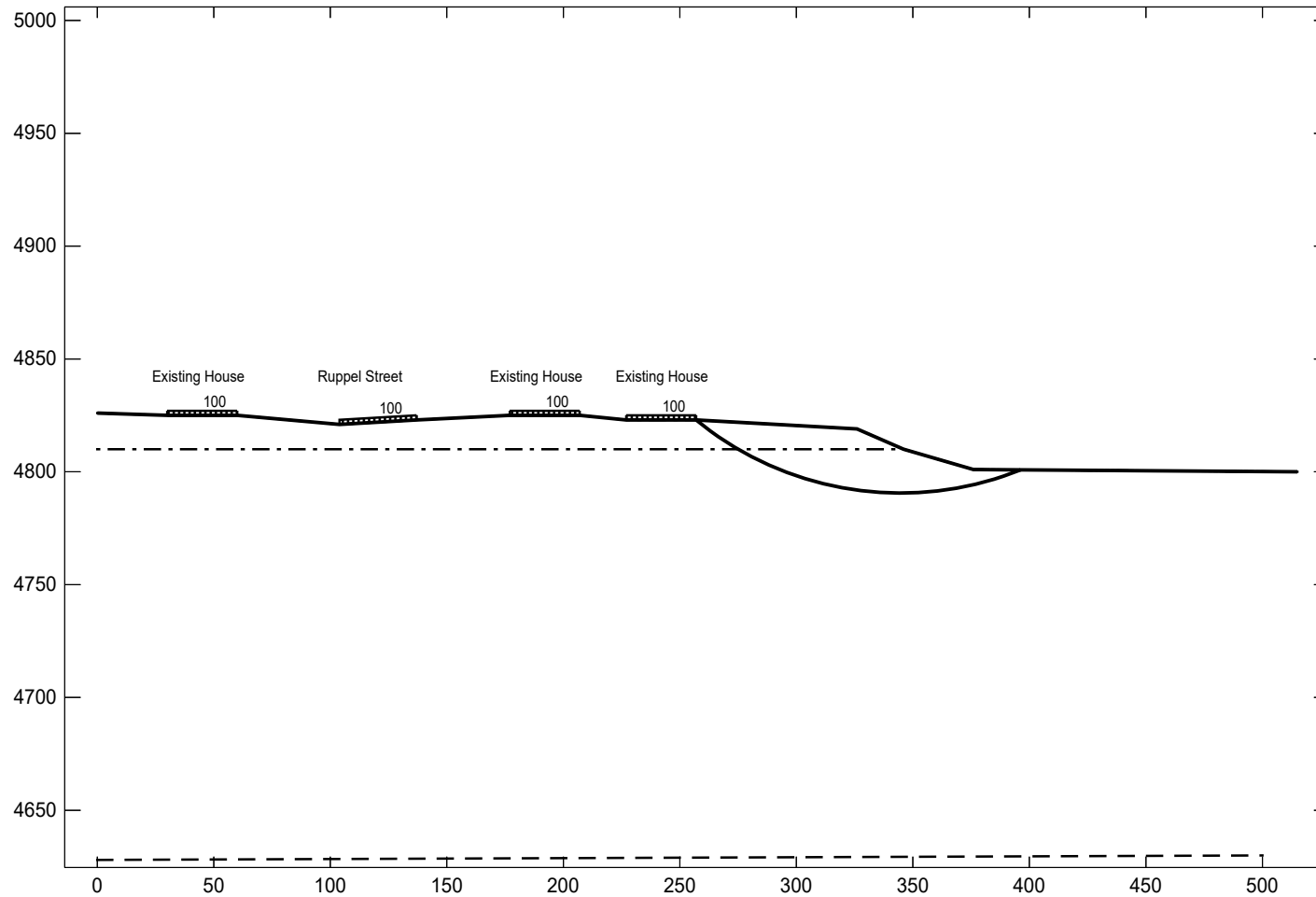
RESULTS: Analysis 1 - Section C

Bishop Simplified Method of Analysis - Circular Failure Surface

Factor of Safety: 5.13

Slice Geometry and Properties (40 slices)

Slice	X-Left	X-S Area	Angle	Width	Base Length	Matl	Cohesion	Phi	Weight	Porewater Force	Normal Stress	Test Factor
1	215.00	2.02	35.7	2.84	3.50	1	0.00	22.0	212.07	0.00	70.64	1.17
2	217.84	6.06	35.7	2.84	3.50	1	0.00	22.0	636.06	0.00	211.89	1.17
3	220.68	10.20	33.0	2.93	3.50	1	0.00	22.0	1070.83	0.00	347.12	1.13
4	223.62	13.91	33.0	2.93	3.50	1	0.00	22.0	1460.52	0.00	473.44	1.13
5	226.55	24.46	30.3	4.01	4.64	1	0.00	22.0	2567.85	0.00	612.62	1.11
6	230.56	14.68	30.3	2.04	2.36	2	600.00	26.0	1562.01	0.00	661.81	1.10
7	232.60	24.97	27.6	3.10	3.50	2	600.00	26.0	2728.80	0.00	779.79	1.07
8	235.70	27.89	27.6	3.10	3.50	2	600.00	26.0	3121.86	0.00	900.46	1.07
9	238.80	31.27	24.9	3.18	3.50	2	600.00	26.0	3566.62	0.00	1023.78	1.06
10	241.98	33.74	24.9	3.18	3.50	2	600.00	26.0	3906.11	0.00	1126.14	1.06
11	245.15	36.68	22.1	3.24	3.50	2	600.00	26.0	4301.20	0.00	1231.49	1.04
12	248.39	38.65	22.1	3.24	3.50	2	600.00	26.0	4582.39	0.00	1314.99	1.04
13	251.64	41.09	19.4	3.30	3.50	2	600.00	26.0	4918.54	0.00	1401.81	1.03
14	254.94	42.54	19.4	3.30	3.50	2	600.00	26.0	5138.11	0.00	1466.13	1.03
15	258.24	32.27	16.7	2.44	2.55	2	600.00	26.0	3925.56	0.00	1527.85	1.02
16	260.68	28.53	16.7	2.13	2.22	2	600.00	26.0	3481.10	0.00	1554.37	1.02
17	262.81	28.90	16.7	2.13	2.22	2	600.00	26.0	3525.77	0.00	1574.69	1.02
18	264.94	46.53	14.0	3.40	3.50	2	600.00	26.0	5677.07	0.00	1604.35	1.01
19	268.34	46.88	14.0	3.40	3.50	2	600.00	26.0	5718.90	0.00	1616.39	1.01
20	271.73	47.43	11.3	3.43	3.50	2	600.00	26.0	5786.84	0.00	1631.56	1.00
21	275.17	47.20	11.3	3.43	3.50	2	600.00	26.0	5758.22	0.00	1623.42	1.00
22	278.60	47.06	8.6	3.46	3.50	2	600.00	26.0	5741.02	0.00	1617.90	1.00
23	282.06	46.23	8.5	3.46	3.50	2	600.00	26.0	5640.15	0.00	1589.22	1.00
24	285.52	45.38	5.8	3.48	3.50	2	600.00	26.0	5536.74	0.00	1562.94	1.00
25	289.00	43.96	5.8	3.48	3.50	2	600.00	26.0	5363.28	0.00	1513.62	1.00
26	292.49	42.40	3.1	3.50	3.50	2	600.00	26.0	5173.35	0.00	1466.27	1.00
27	295.98	40.39	3.1	3.50	3.50	2	600.00	26.0	4927.30	0.00	1396.22	1.00
28	299.48	38.14	0.4	3.50	3.50	2	600.00	26.0	4652.75	0.00	1327.65	1.00
29	302.98	35.53	0.4	3.50	3.50	2	600.00	26.0	4334.99	0.00	1236.92	1.00
30	306.48	32.61	-2.3	3.50	3.50	2	600.00	26.0	3979.01	0.00	1146.91	1.00
31	309.97	29.44	-2.3	3.50	3.50	2	600.00	26.0	3591.09	0.00	1035.59	1.00
32	313.47	25.89	-5.0	3.49	3.50	2	600.00	26.0	3158.52	0.00	923.98	1.01
33	316.96	22.15	-5.0	3.49	3.50	2	600.00	26.0	2702.41	0.00	792.06	1.01
34	320.45	18.03	-7.8	3.47	3.50	2	600.00	26.0	2200.03	0.00	658.87	1.02
35	323.91	13.76	-7.8	3.47	3.50	2	600.00	26.0	1678.17	0.00	506.41	1.02
36	327.38	4.89	-10.5	1.62	1.65	2	600.00	26.0	596.65	0.00	397.23	1.04
37	329.00	6.42	-10.5	2.63	2.68	2	600.00	26.0	782.98	0.00	324.80	1.04
38	331.63	5.07	-10.5	2.63	2.68	2	600.00	26.0	618.00	0.00	261.01	1.04
39	334.26	4.26	-13.2	3.41	3.50	2	600.00	26.0	519.86	0.00	184.12	1.05
40	337.67	1.42	-13.2	3.41	3.50	2	600.00	26.0	173.15	0.00	80.05	1.05
X-S Area:		1128.92	Path Length:		133.01	X-S Weight:		135015.86				



GALENA Version 7.2

Project Native/Pierre Mine
Section D

File: G:\My Drive\1 - My Projects Google\8 Galena - Stability Analysis Models\Native\Pierre\Section D.gmf

Analysis 1

Single Stability Analysis
Method: Bishop Simplified
Surface: Circular

Results

Factor of Safety: 4.92

Edited: 5 Jan 2021 Processed: 5 Jan 2021

Dept of the Interior - Office of Surface Mining

Project: Native/Pierre Mine
 File: G:\My Drive\1 - My Projects Google\8 Galena - Stability Analysis Models\NativePierre\Section D.gmf
 Processed: 05 Jan 2021 08:24:02

DATA: Analysis 1 - Section D

Material Properties (2 materials)

Material: 1 (Mohr-Coulomb Isotropic) - Clay
 Cohesion 0.00 Phi 22.0 UnitWeight 105.00 Ru Auto
 Material: 2 (Mohr-Coulomb Isotropic) - Pierre Shale
 Cohesion 600.00 Phi 26.0 UnitWeight 122.00 Ru Auto

Water Properties

Unit weight of water: 62.400 Unit weight of water/medium above ground: 62.400

Material Profiles (2 profiles)

Profile: 1 (2 points) Material beneath: 1 - Clay
 0.00 4840.00 515.00 4840.00
 Profile: 2 (3 points) Material beneath: 2 - Pierre Shale
 0.00 4810.00 346.00 4810.00 515.00 4810.00

Slope Surface (13 points)

0.00	4826.00	30.00	4825.00	60.00	4825.00	104.00	4821.00	137.00	4823.00
177.00	4825.00	207.00	4825.00	227.00	4823.00	257.00	4823.00	326.00	4819.00
346.00	4810.00	376.00	4801.00	515.00	4800.00				

Phreatic Surface (2 points)

0.00	4628.00	500.00	4630.00
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Failure Surface

Circular surface defined by: XL, XR, R

Intersects: XL:	257.00	YL:	4823.00	XR:	396.27	YR:	4800.85
Centre: XC:	344.71	YC:	4925.62	Radius: R:			135.00

Distributed Loads (4 loads)

Load	X-Left	Pressure	X-Right	Pressure
1	30.00	100.0	60.00	100.0
2	104.00	100.0	137.00	100.0
3	177.00	100.0	207.00	100.0
4	227.00	100.0	257.00	100.0

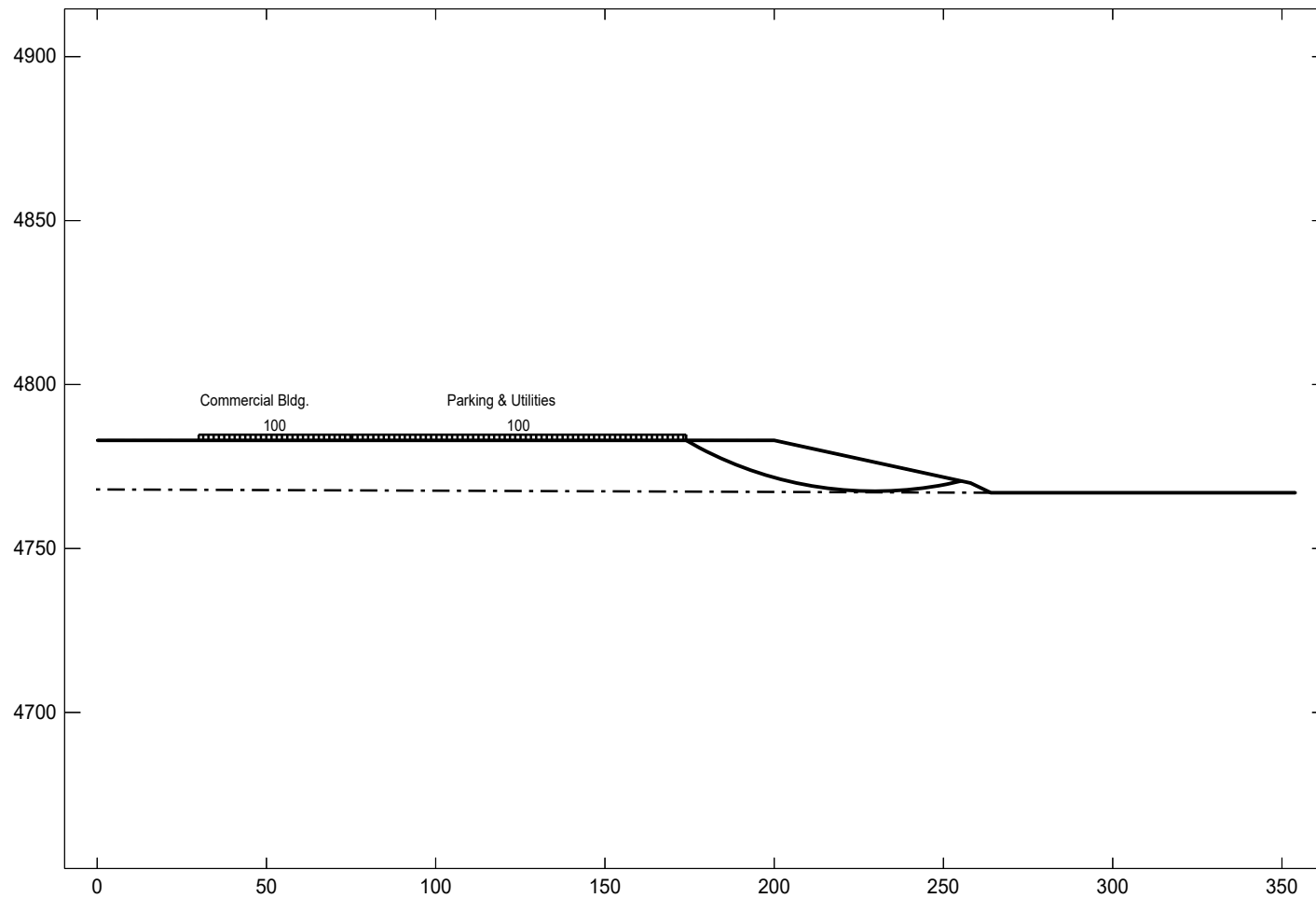
RESULTS: Analysis 1 - Section D

Bishop Simplified Method of Analysis - Circular Failure Surface

Factor of Safety: 4.92

Slice Geometry and Properties (42 slices)

Slice	X-Left	X-S Area	Angle	Width	Base Length	Mat'l	Cohesion	Phi	Weight	PoreWater Force	Normal Stress	Test Factor
1	257.00	3.46	38.9	3.04	3.90	1	0.00	22.0	362.82	0.00	111.95	1.20
2	260.04	10.37	38.9	3.04	3.90	1	0.00	22.0	1088.46	0.00	335.84	1.20
3	263.08	17.76	35.6	3.18	3.90	1	0.00	22.0	1864.51	0.00	554.45	1.16
4	266.26	24.38	35.6	3.18	3.90	1	0.00	22.0	2560.20	0.00	761.33	1.16
5	269.43	26.89	32.2	2.82	3.34	1	0.00	22.0	2823.96	0.00	951.07	1.12
6	272.26	31.46	32.2	2.82	3.34	1	0.00	22.0	3303.15	0.00	1112.47	1.12
7	275.08	11.72	32.2	0.96	1.13	2	600.00	26.0	1235.51	0.00	1140.72	1.11
8	276.04	45.60	28.9	3.42	3.90	2	600.00	26.0	4878.39	0.00	1289.64	1.08
9	279.45	51.38	28.9	3.42	3.90	2	600.00	26.0	5594.48	0.00	1488.27	1.08
10	282.87	58.52	25.6	3.52	3.90	2	600.00	26.0	6457.28	0.00	1695.18	1.06
11	286.39	63.74	25.6	3.52	3.90	2	600.00	26.0	7106.50	0.00	1871.16	1.06
12	289.91	70.38	22.3	3.61	3.90	2	600.00	26.0	7911.14	0.00	2056.50	1.04
13	293.52	74.97	22.3	3.61	3.90	2	600.00	26.0	8484.41	0.00	2208.99	1.04
14	297.14	80.92	19.0	3.69	3.90	2	600.00	26.0	9208.93	0.00	2371.55	1.02
15	300.83	84.82	19.0	3.69	3.90	2	600.00	26.0	9697.78	0.00	2499.66	1.02
16	304.52	89.92	15.7	3.76	3.90	2	600.00	26.0	10322.01	0.00	2638.32	1.01
17	308.28	93.06	15.7	3.76	3.90	2	600.00	26.0	10719.44	0.00	2741.25	1.01
18	312.04	97.18	12.4	3.81	3.90	2	600.00	26.0	11226.78	0.00	2855.03	1.00
19	315.85	99.52	12.3	3.81	3.90	2	600.00	26.0	11526.83	0.00	2932.11	1.00
20	319.67	84.11	9.0	3.17	3.21	2	600.00	26.0	9762.25	0.00	3015.97	1.00
21	322.83	85.12	9.0	3.17	3.21	2	600.00	26.0	9895.78	0.00	3057.46	1.00
22	326.00	36.99	9.0	1.38	1.40	2	600.00	26.0	4309.14	0.00	3059.27	1.00
23	327.38	100.85	5.7	3.88	3.90	2	600.00	26.0	11807.80	0.00	2997.65	1.00
24	331.26	95.57	5.7	3.88	3.90	2	600.00	26.0	11279.32	0.00	2862.92	1.00
25	335.15	90.21	2.4	3.90	3.90	2	600.00	26.0	10739.96	0.00	2736.90	1.00
26	339.05	84.00	2.4	3.90	3.90	2	600.00	26.0	10099.14	0.00	2573.22	1.00
27	342.95	61.12	-0.9	3.05	3.05	2	600.00	26.0	7420.61	0.00	2437.66	1.00
28	346.00	45.05	-0.9	2.38	2.38	2	600.00	26.0	5495.61	0.00	2316.65	1.00
29	348.38	43.26	-0.9	2.38	2.38	2	600.00	26.0	5277.60	0.00	2224.83	1.00
30	350.76	66.54	-4.2	3.89	3.90	2	600.00	26.0	8117.32	0.00	2109.25	1.01
31	354.65	60.87	-4.2	3.89	3.90	2	600.00	26.0	7425.92	0.00	1930.40	1.01
32	358.54	54.45	-7.5	3.87	3.90	2	600.00	26.0	6643.32	0.00	1755.63	1.02
33	362.41	47.98	-7.5	3.87	3.90	2	600.00	26.0	5853.24	0.00	1548.77	1.02
34	366.28	40.71	-10.8	3.83	3.90	2	600.00	26.0	4966.05	0.00	1344.08	1.04
35	370.12	33.48	-10.8	3.83	3.90	2	600.00	26.0	4084.39	0.00	1109.69	1.04
36	373.95	14.79	-14.2	2.05	2.11	2	600.00	26.0	1804.64	0.00	935.37	1.06
37	376.00	17.40	-14.2	2.76	2.85	2	600.00	26.0	2122.22	0.00	819.83	1.06
38	378.76	15.42	-14.2	2.76	2.85	2	600.00	26.0	1880.73	0.00	730.10	1.06
39	381.52	17.22	-17.5	3.72	3.90	2	600.00	26.0	2100.72	0.00	621.96	1.08
40	385.25	12.75	-17.5	3.72	3.90	2	600.00	26.0	1555.70	0.00	470.87	1.08
41	388.97	7.73	-20.8	3.65	3.90	2	600.00	26.0	943.36	0.00	316.72	1.11
42	392.62	2.58	-20.8	3.65	3.90	2	600.00	26.0	314.38	0.00	137.62	1.11
X-S Area:		2154.21	Path Length:		148.36	X-S Weight:		250271.77				



GALENA Version 7.2

Project Native/Pierre Mine
Section E

File: G:\My Drive\1 - My Projects Google\8 Galena - Stability Analysis Models\Native\Pierre\Section E.gmf

Analysis 1

Single Stability Analysis
Method: Bishop Simplified
Surface: Circular

Results

Factor of Safety: 2.62

Edited: 5 Jan 2021 Processed: 5 Jan 2021

Dept of the Interior - Office of Surface Mining

Project: Native/Pierre Mine
 File: G:\My Drive\1 - My Projects Google\8 Galena - Stability Analysis Models\NativePierre\Section E.gmf
 Processed: 05 Jan 2021 08:26:54

DATA: Analysis 1 - Section E

Material Properties (2 materials)

Material: 1 (Mohr-Coulomb Isotropic) - Clay
 Cohesion 0.00 Phi 22.0 UnitWeight 105.00 Ru Auto
 Material: 2 (Mohr-Coulomb Isotropic) - Pierre Shale
 Cohesion 600.00 Phi 26.0 UnitWeight 122.00 Ru Auto

Water Properties

Unit weight of water: 62.400 Unit weight of water/medium above ground: 62.400

Material Profiles (2 profiles)

Profile: 1 (2 points) Material beneath: 1 - Clay
 0.00 4800.00 354.00 4800.00
 Profile: 2 (3 points) Material beneath: 2 - Pierre Shale
 0.00 4768.00 264.00 4767.00 354.00 4767.00

Slope Surface (5 points)

0.00 4783.00 200.00 4783.00 258.00 4770.00 264.00 4767.00 354.00 4767.00

Phreatic Surface (2 points)

0.00 4628.00 500.00 4630.00

Failure Surface

Circular surface defined by: XL, XR, R

Intersects: XL: 174.00 YL: 4783.00 XR: 255.29 YR: 4770.61
 Centre: XC: 229.61 YC: 4875.00 Radius: R: 107.50

Distributed Loads (2 loads)

Load	X-Left	Pressure	X-Right	Pressure
1	30.00	100.0	75.00	100.0
2	75.00	100.0	174.00	100.0

RESULTS: Analysis 1 - Section E

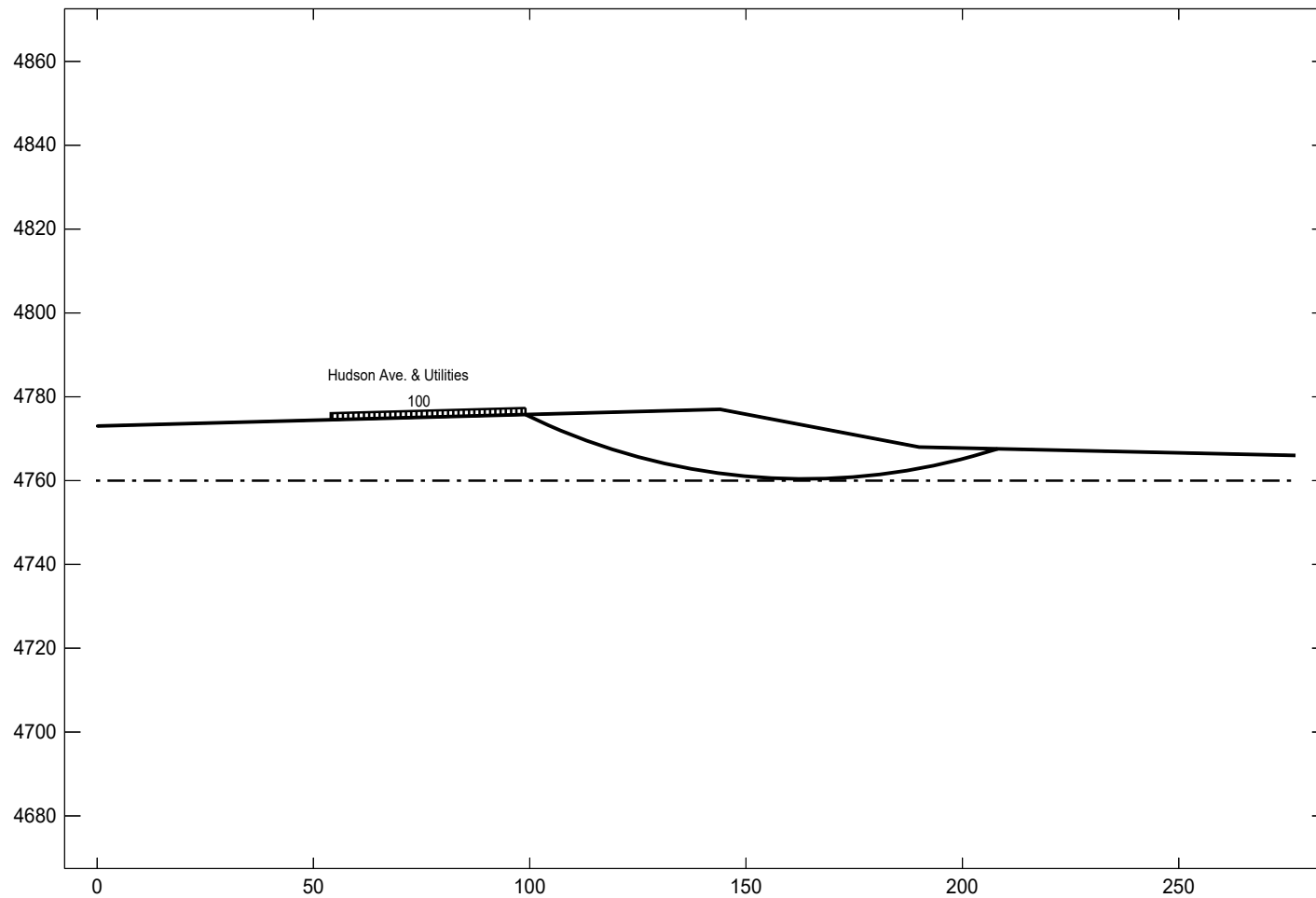
Bishop Simplified Method of Analysis - Circular Failure Surface

Factor of Safety: 2.62

Slice Geometry and Properties (38 slices)

Slice	X-Left	X-S Area	Angle	Width	Base Length	Mat l	Cohesion	Phi	Weight	PoreWater Force	Normal Stress	Test Factor
1	174.00	1.07	30.0	1.92	2.22	1	0.00	22.0	112.02	0.00	53.49	1.06
2	175.92	3.20	30.0	1.92	2.22	1	0.00	22.0	335.97	0.00	160.43	1.06
3	177.85	5.38	27.6	1.97	2.22	1	0.00	22.0	564.62	0.00	265.56	1.04
4	179.81	7.40	27.6	1.97	2.22	1	0.00	22.0	777.06	0.00	365.49	1.04
5	181.78	9.54	25.2	2.01	2.22	1	0.00	22.0	1001.49	0.00	464.88	1.03
6	183.79	11.44	25.2	2.01	2.22	1	0.00	22.0	1201.24	0.00	557.61	1.03
7	185.80	13.50	22.9	2.05	2.22	1	0.00	22.0	1417.87	0.00	650.77	1.02
8	187.84	15.27	22.9	2.05	2.22	1	0.00	22.0	1603.31	0.00	735.89	1.02
9	189.89	17.23	20.5	2.08	2.22	1	0.00	22.0	1808.99	0.00	822.44	1.01
10	191.97	18.85	20.5	2.08	2.22	1	0.00	22.0	1978.73	0.00	899.62	1.01
11	194.05	20.67	18.1	2.11	2.22	1	0.00	22.0	2170.44	0.00	979.22	1.00
12	196.16	22.13	18.1	2.11	2.22	1	0.00	22.0	2323.51	0.00	1048.25	1.00
13	198.27	19.16	15.8	1.73	1.80	1	0.00	22.0	2012.25	0.00	1114.63	1.00
14	200.00	28.98	15.8	2.54	2.64	1	0.00	22.0	3043.30	0.00	1146.64	1.00
15	202.54	24.81	13.4	2.16	2.22	1	0.00	22.0	2604.64	0.00	1163.21	0.99
16	204.70	24.87	13.4	2.16	2.22	1	0.00	22.0	2611.49	0.00	1166.27	0.99
17	206.86	25.06	11.0	2.18	2.22	1	0.00	22.0	2631.12	0.00	1172.14	0.99
18	209.04	24.92	11.0	2.18	2.22	1	0.00	22.0	2616.73	0.00	1165.68	0.99
19	211.22	24.86	8.7	2.19	2.22	1	0.00	22.0	2610.05	0.00	1161.82	0.99
20	213.42	24.51	8.7	2.19	2.22	1	0.00	22.0	2573.80	0.00	1145.69	0.99
21	215.61	24.19	6.3	2.21	2.22	1	0.00	22.0	2540.38	0.00	1131.85	0.99
22	217.82	23.64	6.3	2.21	2.22	1	0.00	22.0	2482.24	0.00	1105.94	0.99
23	220.03	23.07	3.9	2.22	2.22	1	0.00	22.0	2422.28	0.00	1082.06	0.99
24	222.24	22.31	3.9	2.22	2.22	1	0.00	22.0	2342.23	0.00	1046.30	0.99
25	224.46	21.49	1.6	2.22	2.22	1	0.00	22.0	2255.94	0.00	1012.16	1.00
26	226.68	20.52	1.6	2.22	2.22	1	0.00	22.0	2154.21	0.00	966.49	1.00
27	228.89	19.45	-0.8	2.22	2.22	1	0.00	22.0	2042.24	0.00	921.85	1.00
28	231.11	18.28	-0.8	2.22	2.22	1	0.00	22.0	1919.10	0.00	866.28	1.00
29	233.34	16.98	-3.2	2.22	2.22	1	0.00	22.0	1782.55	0.00	810.97	1.01
30	235.55	15.60	-3.2	2.22	2.22	1	0.00	22.0	1638.41	0.00	745.40	1.01
31	237.77	14.09	-5.5	2.21	2.22	1	0.00	22.0	1479.20	0.00	679.45	1.02
32	239.98	12.52	-5.5	2.21	2.22	1	0.00	22.0	1314.46	0.00	603.80	1.02
33	242.19	10.80	-7.9	2.20	2.22	1	0.00	22.0	1133.97	0.00	526.88	1.03
34	244.39	9.05	-7.9	2.20	2.22	1	0.00	22.0	949.73	0.00	441.29	1.03
35	246.59	7.15	-10.3	2.18	2.22	1	0.00	22.0	750.27	0.00	353.27	1.05
36	248.77	5.21	-10.3	2.18	2.22	1	0.00	22.0	547.07	0.00	257.58	1.05
37	250.96	3.16	-12.6	2.17	2.22	1	0.00	22.0	331.45	0.00	158.46	1.06
38	253.12	1.05	-12.6	2.17	2.22	1	0.00	22.0	110.41	0.00	52.79	1.06

X-S Area:		611.38	Path Length:		84.37	X-S Weight:		64194.78				



GALENA Version 7.2

Project Native/Pierre Mine
Section F

File: G:\My Drive\1 - My Projects Google\8 Galena - Stability Analysis Models\Native\Pierre\Section F.gmf

Analysis 1
Single Stability Analysis
Method: Bishop Simplified
Surface: Circular

Results
Factor of Safety: 4.51

Edited: 5 Jan 2021 Processed: 5 Jan 2021

Dept of the Interior - Office of Surface Mining

Project: Native/Pierre Mine
 File: G:\My Drive\1 - My Projects Google\8 Galena - Stability Analysis Models\NativePierre\Section F.gmf
 Processed: 05 Jan 2021 08:29:24

DATA: Analysis 1 - Section F

Material Properties (2 materials)

Material: 1 (Mohr-Coulomb Isotropic) - Clay
 Cohesion 0.00 Phi 22.0 UnitWeight 105.00 Ru Auto
 Material: 2 (Mohr-Coulomb Isotropic) - Pierre Shale
 Cohesion 600.00 Phi 26.0 UnitWeight 122.00 Ru Auto

Water Properties

Unit weight of water: 62.400 Unit weight of water/medium above ground: 62.400

Material Profiles (2 profiles)

Profile: 1 (2 points) Material beneath: 1 - Clay
 0.00 4780.00 277.00 4780.00
 Profile: 2 (2 points) Material beneath: 2 - Pierre Shale
 0.00 4760.00 277.00 4760.00

Slope Surface (4 points)

0.00 4773.00 144.00 4777.00 190.00 4768.00 277.00 4766.00

Phreatic Surface (2 points)

0.00 4628.00 500.00 4630.00

Failure Surface

Circular surface defined by: XL, XR, R

Intersects: XL: 99.00 YL: 4775.75 XR: 208.17 YR: 4767.58
 Centre: XC: 163.44 YC: 4903.41 Radius: R: 143.00

Distributed Loads (1 load)

Load 1 X-Left 54.00 Pressure 100.0 X-Right 99.00 Pressure 100.0

RESULTS: Analysis 1 - Section F

Bishop Simplified Method of Analysis - Circular Failure Surface

Factor of Safety: 4.51

Slice Geometry and Properties (39 slices)

Slice	X-Left	X-S Area	Angle	Width	Base Length	Mat l	Cohesion	Phi	Weight	Porewater Force	Normal Stress	Test Factor
1	99.00	1.80	25.6	2.67	2.96	1	0.00	22.0	189.17	0.00	68.04	1.06
2	101.67	5.40	25.6	2.67	2.96	1	0.00	22.0	567.37	0.00	204.06	1.06
3	104.33	9.03	23.2	2.72	2.96	1	0.00	22.0	948.03	0.00	336.06	1.05
4	107.05	12.40	23.2	2.72	2.96	1	0.00	22.0	1302.07	0.00	461.56	1.05
5	109.76	15.88	20.9	2.76	2.96	1	0.00	22.0	1667.90	0.00	583.86	1.03
6	112.53	19.00	20.9	2.76	2.96	1	0.00	22.0	1995.48	0.00	698.53	1.03
7	115.29	22.29	18.5	2.80	2.96	1	0.00	22.0	2340.87	0.00	810.68	1.02
8	118.09	25.14	18.5	2.80	2.96	1	0.00	22.0	2639.85	0.00	914.22	1.02
9	120.90	28.19	16.1	2.84	2.96	1	0.00	22.0	2959.57	0.00	1015.83	1.01
10	123.74	30.74	16.1	2.84	2.96	1	0.00	22.0	3227.90	0.00	1107.95	1.01
11	126.58	33.50	13.8	2.87	2.96	1	0.00	22.0	3517.40	0.00	1198.70	1.01
12	129.45	35.75	13.8	2.87	2.96	1	0.00	22.0	3753.40	0.00	1279.10	1.01
13	132.32	38.17	11.4	2.90	2.96	1	0.00	22.0	4008.17	0.00	1358.58	1.00
14	135.22	40.10	11.4	2.90	2.96	1	0.00	22.0	4210.38	0.00	1427.12	1.00
15	138.12	42.16	9.0	2.92	2.96	1	0.00	22.0	4427.05	0.00	1495.03	1.00
16	141.03	43.75	9.0	2.92	2.96	1	0.00	22.0	4593.78	0.00	1551.35	1.00
17	143.95	44.49	6.6	2.94	2.96	1	0.00	22.0	4671.28	0.00	1574.45	1.00
18	146.89	43.81	6.6	2.94	2.96	1	0.00	22.0	4599.78	0.00	1550.34	1.00
19	149.83	43.11	4.3	2.95	2.96	1	0.00	22.0	4527.05	0.00	1525.46	1.00
20	152.77	42.06	4.3	2.95	2.96	1	0.00	22.0	4416.59	0.00	1488.21	1.00
21	155.72	40.92	1.9	2.95	2.96	1	0.00	22.0	4296.91	0.00	1450.02	1.00
22	158.68	39.51	1.9	2.95	2.96	1	0.00	22.0	4148.16	0.00	1399.83	1.00
23	161.63	37.93	-0.5	2.96	2.96	1	0.00	22.0	3982.60	0.00	1348.24	1.00
24	164.59	36.15	-0.5	2.96	2.96	1	0.00	22.0	3795.42	0.00	1284.87	1.00
25	167.54	34.15	-2.8	2.95	2.96	1	0.00	22.0	3585.63	0.00	1219.83	1.01
26	170.50	32.01	-2.8	2.95	2.96	1	0.00	22.0	3361.13	0.00	1143.44	1.01
27	173.45	29.61	-5.2	2.94	2.96	1	0.00	22.0	3109.33	0.00	1064.83	1.01
28	176.39	27.13	-5.2	2.94	2.96	1	0.00	22.0	2848.36	0.00	975.47	1.01
29	179.34	24.36	-7.6	2.93	2.96	1	0.00	22.0	2557.53	0.00	883.27	1.02
30	182.27	21.54	-7.6	2.93	2.96	1	0.00	22.0	2261.26	0.00	780.95	1.02
31	185.20	15.42	-9.9	2.40	2.44	1	0.00	22.0	1619.18	0.00	685.11	1.03
32	187.60	13.28	-9.9	2.40	2.44	1	0.00	22.0	1394.65	0.00	590.09	1.03
33	190.00	5.09	-10.0	1.02	1.04	1	0.00	22.0	534.68	0.00	531.82	1.03
34	191.02	13.10	-12.3	2.89	2.96	1	0.00	22.0	1375.65	0.00	485.79	1.04
35	193.91	11.09	-12.3	2.89	2.96	1	0.00	22.0	1164.49	0.00	411.22	1.04
36	196.80	8.82	-14.7	2.86	2.96	1	0.00	22.0	926.19	0.00	331.65	1.06
37	199.66	6.49	-14.7	2.86	2.96	1	0.00	22.0	681.63	0.00	244.08	1.06
38	202.52	3.95	-17.0	2.83	2.96	1	0.00	22.0	414.57	0.00	150.82	1.08
39	205.34	1.32	-17.0	2.83	2.96	1	0.00	22.0	138.09	0.00	50.24	1.08

X-S Area:		978.65	Path Length:		112.33	X-S Weight:		102758.55				