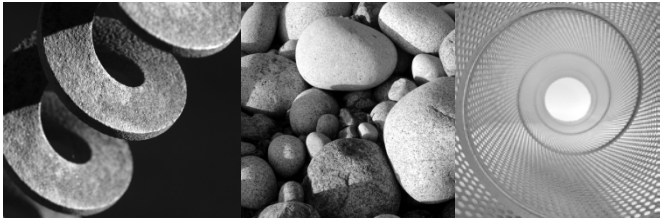

GEI Consultants

Consulting
Engineers and
Scientists

Geotechnical Addendum

2019 Annual Report

Aggregate Industries Morrison Quarry
Permit M-1973-021
Jefferson County, Colorado

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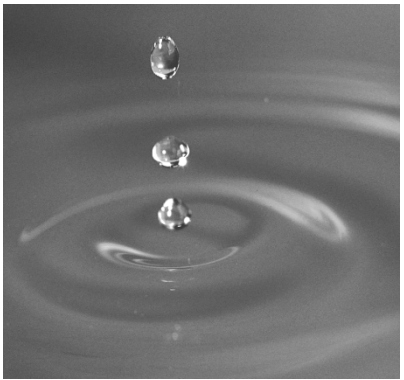

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1. Introduction

This addendum report provides information required by Amendment No. 3 (AM-03) and AM-04 to permit M-1973-021, carried forth to the current AM-05, that allows the Colorado Division of Reclamation, Mining and Safety (DRMS) to review existing and evolving quarry conditions at the Morrison Quarry mine, which is operated by Aggregate Industries (AI). The report summarizes geotechnical observations made by GEI Consultants, Inc. (GEI) field staff on December 12 and 13, 2019, and is a supplement to the "2019 Notice of Intent to Continue Mining Operations/Annual Report."

GEI staff noted and documented exposed rock conditions such as joint and foliation orientation, shear zones, faults, and instability zones for areas mined in 2019. Recommendations for mine highwall configurations are based on field observations made during the site inspections.

1.1 Observational Method

The observational method used for the Morrison Quarry is described in AM-03 and AM-04. The step-wise approach to slope design uses observational data to regularly update quarry highwall configurations by comparing new observations and data to baseline data obtained during previous geotechnical permit addenda. This methodology is used as a practical approach to develop mine highwall designs for rock mass slopes with variable conditions, and has been used for slopes in the North, Central, and South Quarries of the Morrison Quarry.

1.2 Mine Location and Description

The Morrison Quarry is a hard rock aggregate quarry located west of Colorado Highway 8 and approximately 0.5 miles north of U.S. Highway 285 in Morrison, Colorado. The mine location is shown in Figure 1. The mine site is located west of the Dakota hogback along the Front Range west of Denver, Colorado.

The Morrison Quarry consists of three cells; the North Quarry, the Central Quarry, and the South Quarry. Active mining is limited to the South Quarry, and no mining occurred within the North Quarry or Central Quarry in 2019.

1.2.1 *North Quarry*

The North Quarry holds water utilized as mine process water and as raw water storage by the Town of Morrison (Figure 2). Within the North Quarry footprint, the north repository provides storage for undesirable material including waste aggregate from mine operations and damaged or inoperable mine equipment. The North Quarry was mined to an approximate

bottom elevation (El.) of 6220 feet above mean sea level (MSL) utilizing highwalls and benches at a nominal 1H:1V (horizontal to vertical).

1.2.2 *Central Quarry*

The Central Quarry was mined to an approximate bottom El. 6330 feet above MSL utilizing highwalls and benches at a nominal 1H:1V slope or steeper. In 2016, reclamation was effectively completed within the Central Quarry when the southwest corner was backfilled to match the surrounding grade at El. 6500. AI has continued to stockpile material stripped from mining activities within the Central Quarry in addition to jadair fines (a byproduct created during aggregate washing), in stockpiles above El. 6500 (Figure 3). AI plans to utilize this material in future reclamation slopes within the South Quarry.

1.2.3 *South Quarry*

Mining activity continued within the South Quarry in 2019, primarily on the western (east-facing) portions of the quarry. Mining occurred between approximate El. 6800 and 6740 using benching and highwalls, and Figure 4 shows topography developed by AI during the 2019 mining period.

2. 2019 Mining Summary

The following section provides a summary of mining activities performed at Morrison Quarry in 2019.

2.1 North Quarry

Mining in the North Quarry was completed in 2007 and no mining activity occurred in the North Quarry in 2019. The North Quarry is currently being used as a raw water storage reservoir for the Town of Morrison and for production water storage for use by AI. The water level in the pond is approximately three feet below the ground surface at the southeast corner of the North Quarry pit. Figure 2 shows the current configuration of the North Quarry, including the reservoir and the north repository.

2.2 Central Quarry

Mining activity was completed in the Central Quarry in 2001. No mining activity occurred in 2019 and the Central Quarry experienced no major rock disturbances. Reclamation is complete to El. 6500 in the Central Quarry and the south side of the quarry is being used to temporarily stockpile stripped materials including overburden, sillimanitic gneiss, and other undesirable material from the South Quarry to be used as future reclamation backfill material. Figure 3 shows an overview of the Central Quarry.

2.3 South Quarry

Mining operations continued in the South Quarry in 2019 but did not result in an expansion of the 2018 mining footprint, as mining occurred primarily downward within the existing benches. Mining occurred primarily on the western (east-facing) and southern (north-facing) portions of the South Quarry. The general configuration of the South Quarry and areas mined in 2019 is shown in Figure 4 and Figure 7.

Mining in the South Quarry occurred between approximate El. 6740 and 6800. Mining in the South Quarry was primarily performed on the west and south ends of Bench 6740 to create a highwall and bench configuration similar to Bench 6800. Mining from Bench 6800 down to Bench 6740 was generally performed to the west and is still ongoing. The current width of Bench 6800 was variable at the time of the site inspection due to active mining operations. Figure 7 shows the western highwall configuration at the time of the field investigation.

3. 2019 Field Observations

The following section includes observations of mine conditions made by GEI staff on December 12 and 13, 2019. Joint and foliation orientations, highwall trends, and rock mass rating (RMR) classification estimates are included for areas exposed by mining operations in 2019. Unusual rock features exposed in the highwalls such as shear zones, intrusions, adversely dipping foliation, and areas of potential instability were also documented.

3.1 North Quarry

No mining occurred within the North Quarry in 2019 and no major rock disturbances were noted. No new orientation data was obtained during the 2019 review, but the existing highwalls and benches, the repaired North Slope, and the north repository area were observed. Local raveling of rocks and minor instabilities were noted within the main trunk of the North Quarry. These instabilities and raveling events are assumed to be a result of adverse joint conditions, rock alteration, or freeze thaw weathering cycles. Typically, rocks loosened in this manner will be small (usually less than 18 inches) and will likely be contained on the benches. No instability was noted on the North Slope fill or the north repository, and no large-scale seepage was observed within the North Quarry.

3.2 Central Quarry

No mining activity in the Central Quarry occurred in 2019 and no new orientation data was collected during the 2019 inspection. Local raveling of rocks and minor instabilities were evident within the Central Quarry but no new slope failures were observed. These instabilities and raveling events are assumed to be a result of adverse joint conditions, rock alteration, or freeze thaw weathering cycles. Typically, rocks loosened in this manner will be small (usually less than 18 inches) and will likely be contained on the benches.

The existing bottom grade of the Central Quarry is approximately El. 6500. Excess material is being temporarily stockpiled in the south end of the quarry above El. 6500 for future use in South Quarry reclamation.

3.2.1 *Groundwater Seepage*

Minor groundwater seepage, visible in the west (east facing) highwall at approximate El. 6600 feet, was noted as a changed condition in the 2013 geotechnical addendum. A year-by-year comparison of the seepage area is shown in Figure 5. The seepage was not observed in 2017, 2018, or 2019.

3.2.2 *Reclamation Slope Instability*

During a site visit in June 2018, GEI noted a scarp on a reclaimed slope above the access road west of the Central Quarry. The scarp is visible from the mine office (Figure 29). When the area was originally inspected in June 2018, a 2-foot-high head scarp and flank scarp were observed, which indicated movement of a section of slope approximately 150 feet wide between approximate El. 6675 and 6725. It is not known when the initial movement occurred. The reclaimed slope was covered in snow during the 2019 Annual Report inspection, and the scarp was not observed.

GEI installed a monitoring well near the area of the reclamation slope instability in December 2019 to record groundwater levels in the region. A photograph of the monitoring well is shown in Figure 6.

3.3 South Quarry

Mining occurred in the South Quarry in 2019, but the active mining footprint was not expanded. Highwalls directly below Bench 6800 were mined west of the main haul road. According to AI, no reclamation occurred in the South Quarry in 2019. A distant view of the South Quarry from the east with previously reclaimed benches highlighted is shown in Figure 8.

Photos of South Quarry highwalls between El. 7000 and El. 6800 were taken using an Unmanned Aerial System (UAS) on December 12, 2019. Benches above El. 7000 have not been mined in several years and photos of each bench (reclaimed and unreclaimed) above El. 7000 are included in the Geotechnical Addendum to the 2017 Annual Report (GEI, 2018a). The locations of benches 6840 and 6800 are shown in Figure 7, and photos of the benches are shown in Figure 9 through Figure 16.

3.3.1 *Rock Type*

The rock type observed within the South Quarry is consistent with rock found in the North Quarry and Central Quarry. It is generally described as fine- to medium-grained granitic gneiss or biotite gneiss. Occasional pegmatite intrusions are present in the granitic gneiss. Shear zones are also present and visible in widths that range from several inches to approximately 20 feet.

The rock is typically slightly weathered to moderately weathered. Some highwall sections are more highly weathered. These sections are typically in areas proximal to the original (pre-mining) ground surface and along fractures and discontinuities. Several localized highwall sections are relatively unweathered. These highwall sections are typically in areas adjacent to the current mine pit floor and deep within the quarry.

Two prominent joint sets are visible throughout the South Quarry, and one additional joint set is related to foliations. Joint sets are generally spaced several inches to approximately 10 feet. The typical aperture of the primary joint sets is approximately one-tenth to one quarter of an inch. Larger apertures are likely the result of disturbance from mine blasting. Several observed joint sets had localized aperture values less than one-tenth of an inch. The rock surfaces of the prominent joint sets are typically slightly rough to rough; localized smooth areas are present, but the overall discontinuity is slightly rough to rough. Iron staining is present on most joint faces, with less staining typically observed at lower elevations. Most joints generally do not contain infill material.

Foliation spacing ranges from one half of an inch to several feet. Foliation plane surfaces are generally characterized similarly to the two prominent joint sets: the surface is slightly rough to rough, and slightly weathered to moderately weathered with iron oxide staining. Infill material is not present except in localized incidences.

3.3.2 *Bench 6840*

Mining from Bench 6840 was last performed in 2018. During the December 2019 site visit, GEI staff noted rock fall from Bench 6840 and debris that, in some places, extends to the edge of the lower bench (Bench 6800).

Bench 6840 could not safely be accessed by GEI staff due to narrow bench width, the potential for rock fall, and active mining operations. Photos of the highwall above Bench 6840 were taken with a UAS on December 12, 2019. The photos were processed using Pix4D software to create an orthoplane, an orthorectified (uniform scale) image of a vertical object. This highwall orthoplane was then divided to fit on multiple figures, viewed from left to right (Figure 9 through Figure 11). Notable features identified in the image include a mafic dike on the bottom right side of Figure 9, a minor area of adversely dipping foliation in the upper middle of Figure 10, a near-vertical pegmatite intrusion in the bottom right of Figure 10, a shear zone on the lower right side of Figure 10 above a debris pile, and a pegmatite intrusion on the upper left side of Figure 11.

3.3.3 *Bench 6800*

Mining from Bench 6800 was last performed in 2018. During the December 2019 site visit, GEI staff noted rock fall and rock debris loading that, in some places, extends to the edge of the bench.

Bench 6800 could not safely be accessed by GEI staff due to narrow bench width and the potential for rock fall. Photos of the highwall above Bench 6800 were taken with a UAS on December 12, 2019. The photos were processed using Pix4D software to create an orthoplane, an orthorectified (uniform scale) image of a vertical object. This highwall orthoplane was then divided to fit on multiple figures, viewed from left to right (Figure 12 through Figure 16). Notable features identified in the image include a minor, localized area

of adversely dipping foliation in the upper left side of Figure 14 and a shear zone on the upper right side of Figure 15.

The highwall above Bench 6800 is the first highwall in the upper South Quarry to exhibit zones of sillimanitic gneiss (GEI, 2018c), which is a type of rock that can be highly friable and has been observed in the Central Quarry and lower benches of the South Quarry. The sillimanitic gneiss has low durability and is typically waste material.

3.3.4 *Scanline Surveys*

Scanline surveys involve measuring and describing discontinuities intersecting the surface of an exposed highwall to determine rock mass characteristics. For safety reasons the highwalls are not approached during the inspection, and measurements were approximated using a Brunton Compass. Field measurements included approximated joint and foliation orientation and dip, overall highwall trends, and rock mass rating (RMR) classification estimates. In addition, unusual rock features exposed in the highwalls such as shear zones, intrusions, adversely dipping foliation, and areas of potential instability are documented.

Scanline surveys were performed by GEI field staff on the highwalls above Bench 6740. The scanline locations and stationing are shown in Figure 4. Photos of the highwalls were taken with a UAS on December 12, 2019. The photos were processed using Pix4D software to create an orthoplane, an orthorectified (uniform scale) image of a vertical object. Each highwall orthoplane was then divided to fit on multiple figures, viewed from left to right (Figure 17 through Figure 27). Approximate station callouts are included in each figure.

3.3.4.1 Methodology

Dip and orientation data were gathered using a Brunton Compass with a 9 degree east magnetic declination and strike direction was established using the right-hand rule. The right-hand rule is an arbitrary standardization that states that of the two opposing strike directions of a joint face, the strike that is 90 degrees to the right of the dip direction shall be selected. Measurements were estimated a safe distance from the highwalls and excavated areas to address safety considerations.

RMR classification is determined from highwall conditions noted with the following parameters and associated point scales (numbers in parentheses):

- Estimated Strength of Intact Rock Material
  - Very High (15 points): >36,260 psi
  - High (12): 14,500 – 36,260 psi
  - Medium High (7): 7,250 – 14,500 psi
  - Moderate (4): 3,625 – 7,250 psi
  - Low (2): 725 – 3,625 psi

- Very Low (1): 145 – 725 psi

- Estimated Drill Core Quality (RQD)
  - Excellent Quality (20 points): 90 – 100%
  - Good Quality (17): 75 – 90%
  - Fair Quality (13): 50 – 75%
  - Poor Quality (8): 25 – 50%
  - Very Poor Quality (3): <25%

- Spacing of Discontinuities
  - Very Wide (20 points): >6.5 feet
  - Wide (15): 2 – 6.5 feet
  - Moderate (10): 8 – 24 inches
  - Close (8): 2.4 – 8 inches
  - Very Close (5): <2.4 inches

- Groundwater Conditions
  - Inflow, liters per 10 min, or water pressure

- Discontinuity Persistence
  - Very Low (6 points): <3.3 feet
  - Low (4): 3.3 – 9.9 feet
  - Medium (2): 9.9 – 33 feet
  - High (1): 33 – 66 feet
  - Very High (0): >66 feet

- Discontinuity Separation (Aperture)
  - Very Tight Joints (6 points): <0.003 inches
  - Tight Joints (5): 0.003 – 0.02 inches
  - Moderately Open Joints (4): 0.02 – 0.1 inches
  - Open Joints (1): 0.1 – 0.4 inches
  - Very Wide Aperture (0): >0.4 inches

- Discontinuity Roughness
  - Very Rough Surfaces (6 points): VR
  - Rough Surfaces (5): R
  - Slightly Rough Surfaces (3): SR
  - Smooth Surfaces (1): SM
  - Slickened Surfaces (0): SL

- Discontinuity Filling (Gouge)
  - Type – clay, staining, shear, etc.
  - Thickness
  - Estimated Compressive Strength
  - Seepage – none, moist, dripping, etc.

- Discontinuity Wall Face Weathering
  - Unweathered (6 points): UW
  - Slightly Weathered (5): SW
  - Moderately Weathered (3): MW
  - Highly Weathered (1): HW
  - Completely Weathered (0): CW
  - Residual Soil (0): RS

The lowest point value for each RMR parameter are tallied, resulting in a lower bound RMR value. Similarly, the highest point value for each parameter is tallied to give an upper bound value. Thus, for a given highwall, a range of overall RMR values and classifications are reported. The classifications are as follows:

RMR Value	RMR Classification
0 – 20	Very Poor
21 – 40	Poor
41 – 60	Fair
61 – 80	Good
81 – 100	Very Good

Detailed RMR data sheets for the 2019 scanline surveys are included in Appendix A. Average rock strength estimated using the RMR values indicate rock of **poor to fair quality** for the highwalls surveyed. Brief descriptions of scanline observations including notes on unusual rock features such as shear zones, intrusions, adversely dipping foliation, and areas of potential instability are presented below.

3.3.4.2 Bench 6740

The exposed highwall above Bench 6740 is approximately 2,000 feet long and was divided into eleven distinct scanlines during the inspection. The highwall geology consisted primarily of granitic and biotite gneiss with pegmatite intrusions. Mafic intrusions were not observed exposed in the highwall above Bench 6740 but can be seen above Bench 6800 on the south side of the highwall, beyond the extent of Bench 6740. Variable joint sets were present throughout the scanlines. A summary of the scan lines follows below.

- Scanline A (Sta. 0+00 to Sta. 3+00) trended 350 degrees. The scanline was unmappable from Sta. 0+00 to 3+00 due to debris from blasting operations. Scanline A is shown in Figure 17.

- Scanline B (Sta. 3+00 to Sta. 4+00) trended 7 degrees. Foliations exhibited a strike of about 100 degrees with dips ranging from 12 to 18 degrees. Two primary joint sets were evident. The first primary set exhibited an average strike of 15 degrees and an average dip of 73 degrees. The second set exhibited an average strike of 292 degrees and an average dip of 82 degrees. Very little to no oxide staining was observed in Scanline B. The RMR classification is Poor to Fair. Scanline B is shown in Figure 18.

- Scanline C (Sta. 4+00 to Sta. 4+75) trended 0 degrees. Foliations exhibited a strike ranging from 200 to 320 degrees with dips ranging from 40 to 325 degrees. Two primary joint sets were evident. The first primary joint set exhibited an average strike of 181 degrees and an average dip of 81 degrees. The second primary joint set exhibited an average strike of 101 degrees and an average dip of 76 degrees. A large area of iron oxide staining was present in the top several feet of the highwall. The RMR classification is Poor to Fair. Scanline C is shown in Figure 19.

- Scanline D (Sta. 4+75 to Sta. 6+50) trended 260 degrees. Foliations exhibited a strike ranging from 80 to 124 degrees with dips ranging from 8 to 35 degrees. Two primary joint sets were evident. The first primary joint set exhibited an average strike of 340 degrees and an average dip of 80 degrees. The second primary joint set exhibited an average strike of 255 degrees and an average dip of 83 degrees. Widespread iron oxide staining was present in the upper portions of the highwall. Minor, localized areas of adversely dipping foliation were present. The RMR classification is Very Poor to Fair. Scanline D is shown in Figure 20.

- Scanline E (Sta. 6+50 to Sta. 8+00) trended 240 degrees. The scanline was unmappable from about Sta. 7+00 to 8+00 on the bottom half of the highwall due to a debris pile resulting from uncontrolled blasting. Foliations exhibited a strike ranging from 102 to 125 degrees with dips ranging from 17 to 30 degrees. Two primary joint sets were evident. The first primary joint set exhibited an average strike of 196 degrees and an average dip of 64 degrees. The second primary joint set exhibited an average strike of 259 degrees and an average dip of 53 degrees. Widespread iron oxide staining was present throughout the entire scanline. The RMR classification is Poor to Fair. Scanline E is shown in Figure 21.

- Scanline F (Sta. 8+00 to Sta. 9+00) trended 105 degrees. Foliations exhibited a strike ranging from 13 to 134 degrees with dips ranging from 12 to 27 degrees. Two primary joint sets were evident. The first primary set exhibited an average strike of 176 degrees and an average dip of 56 degrees. The second primary set

exhibited an average strike of 296 degrees and an average dip of 76 degrees. Widespread iron oxide staining was present. A localized area of sillimanitic gneiss was visible near the base of the highwall, at approximately Sta. 9+00, near the corner of the highwall. The RMR classification is Poor to Fair. Scanline F is shown in Figure 22.

- Scanline G (Sta. 9+00 to Sta. 10+50) trended 5 degrees. Foliations exhibited a strike ranging from 0 to 347 degrees with dips ranging from 4 to 90 degrees. Two primary joint sets were evident. The first set exhibited an average strike of 99 degrees and an average dip of 58 degrees. The second primary set exhibited an average strike of 226 degrees and an average dip of 76 degrees. Localized iron oxide staining was present in the middle to lower sections of the scanline. Groundwater seepage was present from the base of the wall to a height of about two-thirds up the highwall, from approximately Sta. 9+00 to 9+25. The RMR classification is Poor to Fair. Scanline G is shown in Figure 23.

- Scanline H (Sta. 10+50 to Sta. 15+25) trended 0 degrees. The scanline was largely unmappable due to a large debris field covering all but the top 5 feet of the highwall. Two primary joint sets were visible at the top of the highwall. The first primary set exhibited an average strike of 25 degrees and an average dip of 53 degrees. The second primary set exhibited an average strike of 270 degrees and an average dip of 84 degrees. The RMR classification was not estimated due to the debris field. Scanline H is shown in Figure 24.

- Scanline I (Sta. 15+25 to Sta. 18+00) trended 10 degrees. Foliations exhibited a strike ranging from 153 to 182 degrees with dips ranging from 12 to 24 degrees. Two primary joint sets and a secondary joint set were evident. The first primary set exhibited an average strike of 250 degrees and an average dip of 69 degrees. The second primary set exhibited an average strike of 202 degrees and an average dip of 75 degrees. The secondary joint set exhibited an average strike of 229 degrees and an average dip of 83 degrees. Localized iron oxide staining was present near the top of the highwall. The RMR classification is Poor to Good. Scanline I is shown in Figure 25.

- Scanline J (Sta. 18+00 to Sta. 18+75) trended 75 degrees. Foliations exhibited a strike ranging from 102 to 242 degrees with dips ranging from 20 to 41 degrees. Two primary joint sets were evident. The first primary set exhibited an average strike of 338 degrees and an average dip of 74 degrees. The second set exhibited an average strike of 95 degrees and an average dip of 81 degrees. Little to no iron oxide staining was present. A pegmatite intrusion was visible in the highwall at approximately Sta. 18+00, near the corner of the highwall. In general, the pegmatite intrusion separated more fractured rock on the south from more massive

rock on the north. The RMR classification is Poor to Fair. Scanline J is shown in Figure 26.

Scanline K, from Sta. 18+75 to 20+00 is obscured by overburden soil as the highwall tapers in height to meet the existing grade of the haul road to the north end of the South Quarry and was therefore unmappable. Scanline K is shown in Figure 27.

The highwall above Bench 6740 exhibits minor, localized zones of sillimanitic gneiss, which is a type of rock that can be highly friable and has been observed in the Central Quarry and lower benches of the South Quarry.

3.3.5 *Bench 6650 Instability*

In March 2017, an approximately 75-foot-wide section on the east side of Bench 6650 dropped 3 feet relative to adjacent sections of the bench during blasting on an adjacent section of the bench and mining in that area of the South Quarry has not resumed.

GEI evaluated the instability in 2017 and recommendations for mitigation are provided in AM-06 (GEI, 2018b). The area near the instability has been monitored monthly since June 2018 using 3 survey control points located near the previous slope failure.

During the 2018 site visits, the bench instability appeared unchanged from March 2017 (GEI, 2018c). One of the surveying control points is in a 25-foot-wide and 3-foot-deep depression on Bench 6675, north of the instability in Bench 6650. Data collected between June and November 2018 showed little to no movement at this control point.

GEI installed several monitoring wells near the Bench 6650 instability in the South Quarry to record groundwater levels. Photos of the monitoring wells are shown in Figure 28. The southernmost monitoring well was covered at the time of the site visit.

4. Results and Recommendations

4.1 Summary of Results

In areas surveyed for the 2019 Geotechnical Addendum, no conditions were observed that indicate the potential for large-scale slope failures. There is a low probability of large wedge or toppling failures due to the joint and foliation orientation and RMR values observed in the headwalls. Additionally, there is a low probability of large plane failures along foliation surfaces that can occur when the foliation surface dips into the highwall face at angles of 38 degrees or greater. There are areas where unfavorable foliation conditions were observed or where small-scale wedge or toppling failures could occur, but the resulting blocks are anticipated to be relatively small and contained on the benches. Some of the unfavorable foliation orientations will likely change during mining operations due to the variable nature of the foliation planes; however, small-scale toppling or wedge conditions are likely to persist during mining.

AM-03 established requirements for rock stability at the Morrison Quarry. Granitic and biotite gneiss should be considered "competent"; rock and shear zones or highly weathered rock should be considered "poor" rock if the zones have the ability to decrease the overall stability of quarry highwalls and/or benches. The observed conditions in the recently-mined areas of the South Quarry are of predominantly "competent" rock quality. Localized "poor" zones were observed and are typically the result of highwall proximity to existing (pre-mining) grade or zones of sillimanitic gneiss.

In the South Quarry, rock types observed included biotite and granitic gneiss with localized pegmatitic or mafic intrusions. Most of the rock observed in the highwalls appeared fresh to moderately weathered, with exceptions being highwalls close to pre-mining topography and the localized zones of sillimanitic gneiss on Bench 6800 and 6740. Highwall orientations, typically east-facing or north-facing, along with observed joint and foliation orientations indicate favorable conditions to continue mining in accordance with the current mine plan.

Kinematic analyses using field observation data support the above conclusions. Stereonets created using the Rocscience Dips software program are provided in Appendix B.

4.2 Recommendations

4.2.1 *North Quarry*

Based on observations made during the December 2019 field inspections, GEI's familiarity with the site, and review of previous geotechnical addenda, the North Quarry experienced little change in finished slope characteristics in 2019. Only small-scale, localized rockfall and highwall raveling occurred during the last year, and these occurrences are considered minor.

GEI recommends that AI continue to monitor the North Quarry highwalls for signs of instability. While localized tension cracks observed in 2013 near the quarry office safe zone were not visible during the 2019 review, this area should also be monitored for signs of instability such as visible slope movement and/or tension cracks. The condition of the main trunk of the North Quarry is expected to remain stable during the 2020 mining year with continued small-scale rockfall and highwall raveling expected to occur.

Observations in the North Quarry on December 12 and 13, 2019 indicate:

- No major failures occurred last year;
- Minor, localized sloughing and raveling occurred;
- Nearly all localized rockfall was contained on the benches; and
- Continued observation of the localized rockfall areas and the reclaimed bench near the mine office for indications of slope instability is recommended for 2019.

4.2.2 *Central Quarry*

Based on observations made during the December 2019 field inspection, GEI's familiarity with the site, and review of previous geotechnical addenda, the Central Quarry experienced little change in finished slope characteristics during 2019. Only small-scale, localized rockfall and highwall raveling occurred during the last year, which is considered minor. If the groundwater seepage previously observed at El. 6600 returns, it should be monitored by AI for unusual increases in flow in 2020.

The instability previously observed in the Central Quarry on the reclaimed slope was covered with snow during the December 2020 inspection and not visible. The unstable slope is limited to surficial deposits and is not considered to present a long-term stability risk to the Central Quarry. Infiltration caused by heavy precipitation or snowmelt could be sufficient to mobilize the slide in the future. AI mine staff should monitor the slope for changing conditions, especially after heavy precipitation. GEI recommends performing a detailed slope stability evaluation and ongoing monitoring of groundwater levels in the area near the slide.

The condition of the Central Quarry is expected to remain stable during the 2020 mining year, and localized small-scale rockfall and highwall raveling is expected to occur.

Observations in the Central Quarry on December 12 and 13, 2019 indicate:

- No major failures occurred last year;
- Minor, localized sloughing and raveling occurred;
- Nearly all rockfall was contained on the benches; and
- The stabilized slope in the northeast section of the Central Quarry did not exhibit any instability or large erosional features.

4.2.3 *South Quarry*

The South Quarry experienced some changes to benches between El. 6800 and 6740 but most of the South Quarry remained unchanged in 2019. Mining did increase the depth or the overall footprint of the South Quarry. Observations in the South Quarry on December 12 and 13, 2019 indicate:

- No major failures occurred last year;
- No further movement of areas around the Bench 6650 instability occurred;
- Minor, localized sloughing and raveling occurred;
- Nearly all rockfall was contained on the benches;

The following are recommendations for AI concerning specific areas of the South Quarry:

4.2.3.1 Bench 6740

Accumulated rock debris on Bench 6950 may limit the amount of rock fall that can be captured contained on the lower benches. While the amount of rock debris on Bench 6740 does not appear to be significantly more than the amount observed in January 2018, AI should continue to monitor for signs of increased buildup, which may indicate instability in upper highwalls and reduced capacity to mitigate falling blocks on lower benches.

Benches 6900 and 6800 could serve as an important bench for containing rock fall if its current width of 40 to 50 feet is maintained, and if large rock debris piles are cleared periodically. Extra caution should be exercised when working near or below areas of adversely dipping foliations and/or excessive rock fall accumulation. If evidence of instability or movement in these areas is observed, further evaluation is recommended.

4.2.3.2 Bench 6800 Sillimanitic Gneiss

The extent of sillimanitic gneiss in the highwalls is expected to increase with depth based on three-dimensional geologic models GEI created in 2017 and 2018. Recommendations for creating stable, final configuration highwalls containing varying amounts of sillimanitic gneiss are outlined in AM-06. GEI will continue to monitor newly exposed highwalls for sillimanitic gneiss during monthly site visits in 2020.

4.2.3.3 Bench 6650 Instability

AI mine staff should continue to monitor Bench 6650 for signs of instability if any work activities are planned to occur in the area. Extra caution should be exercised when working near or below the instability zone due to the potential for uncontrolled movement. Additionally, ongoing monitoring of groundwater levels in the monitoring wells in this area is recommended.

5. References

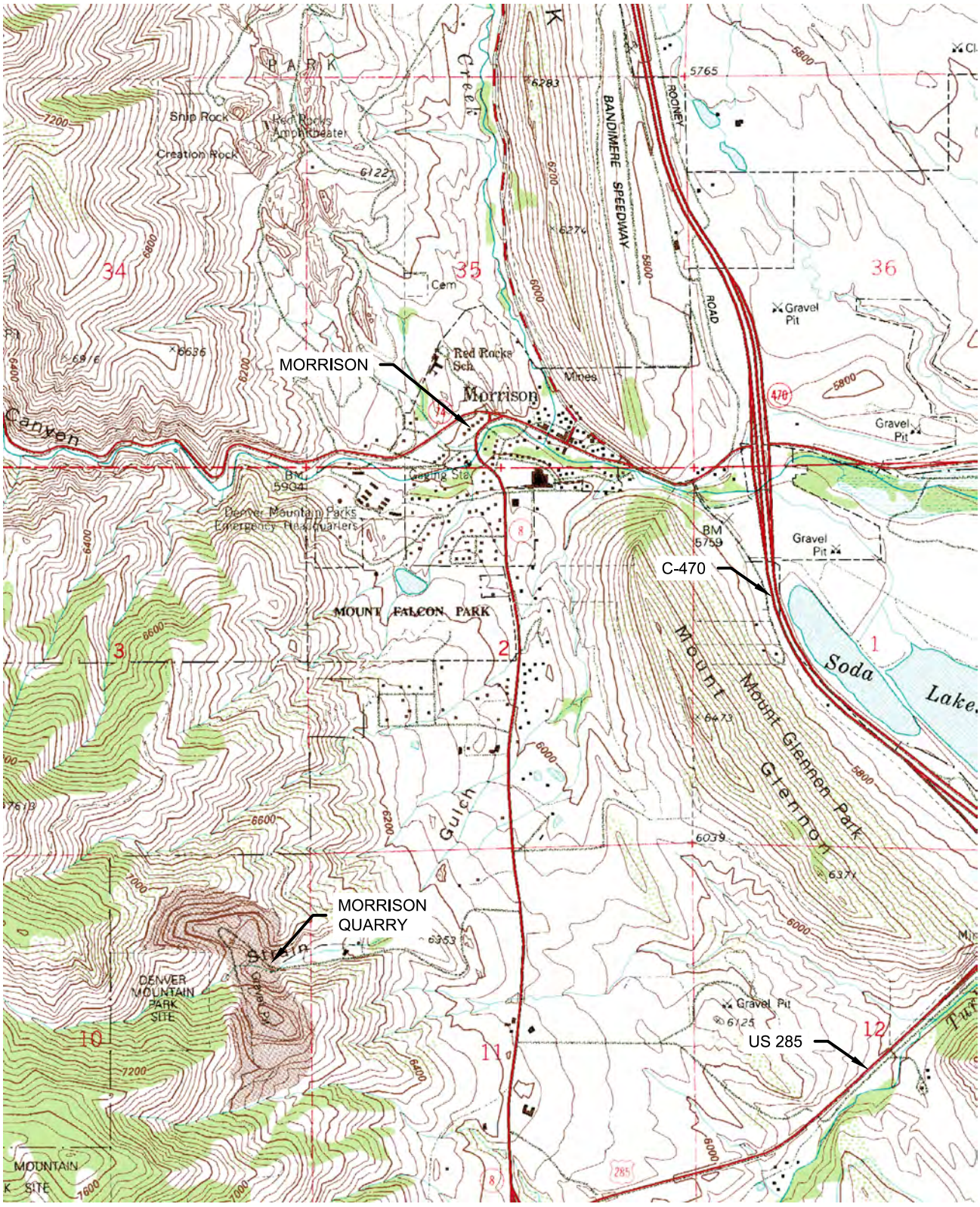
GEI Consultants, Inc. (2018a). “Geotechnical Addendum, 2017 Annual Report, Aggregate Industries Morrison Quarry,” prepared for Aggregate Industries, January.

GEI Consultants, Inc. (2018b). “Sixth Amendment (AM-06) to Permit M-1973-021, Aggregate Industries Morrison Quarry” prepared for Colorado Division of Reclamation Mining & Safety, August.

GEI Consultants, Inc. (2018c). “Geotechnical Addendum, 2018 Annual Report, Aggregate Industries Morrison Quarry,” prepared for Aggregate Industries, December.

Roscience, *DIPS* Stereographic Projection Program, version 7.0

Scott, Glenn R., Geologic Map of the Morrison Quadrangle, Jefferson County, Colorado 1972.

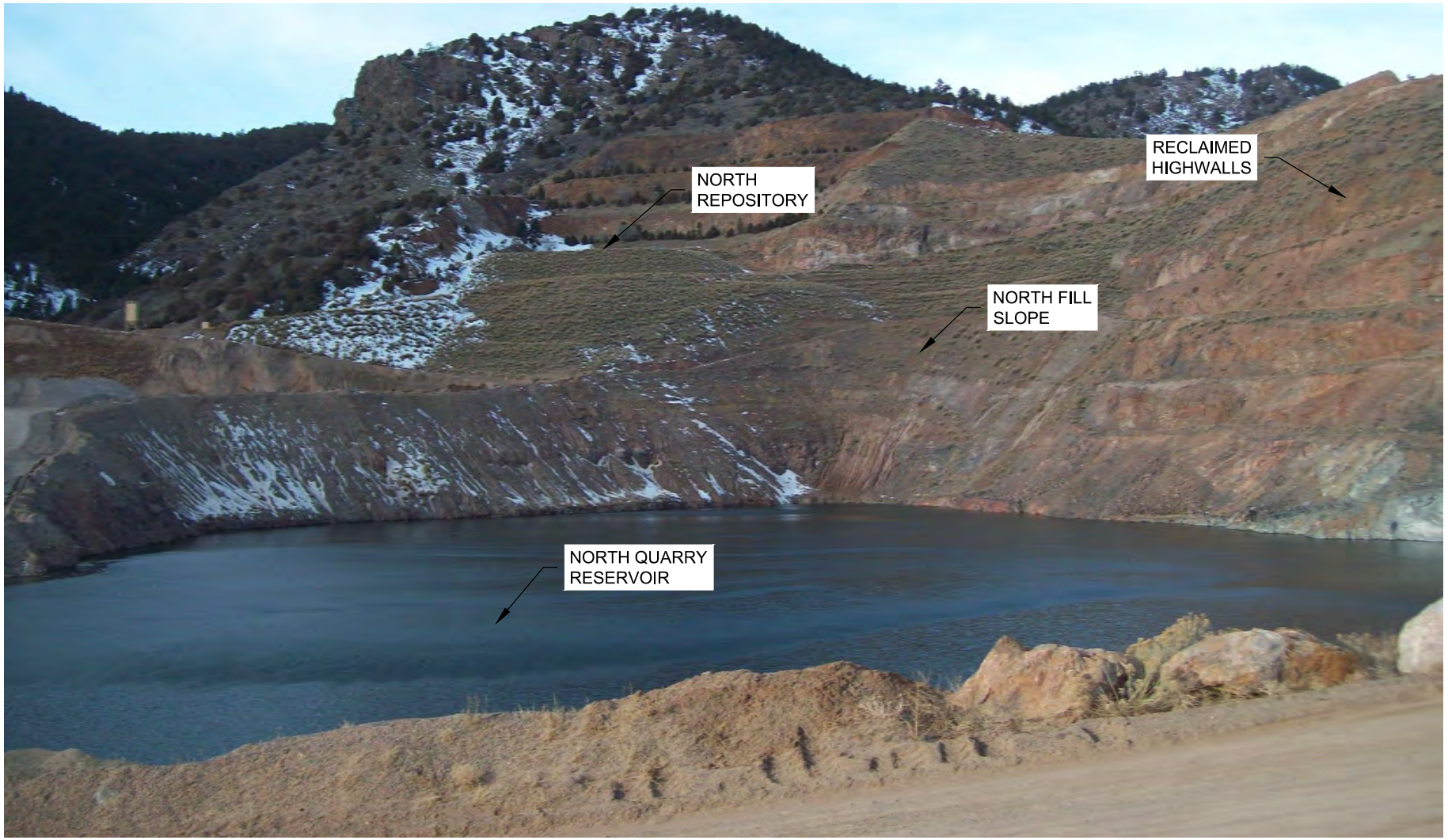


SOURCE:
USGS DIGITAL RASTER GRAPHIC,
MORRISON QUADRANGLE

NOTE: DRAWING NOT TO SCALE.

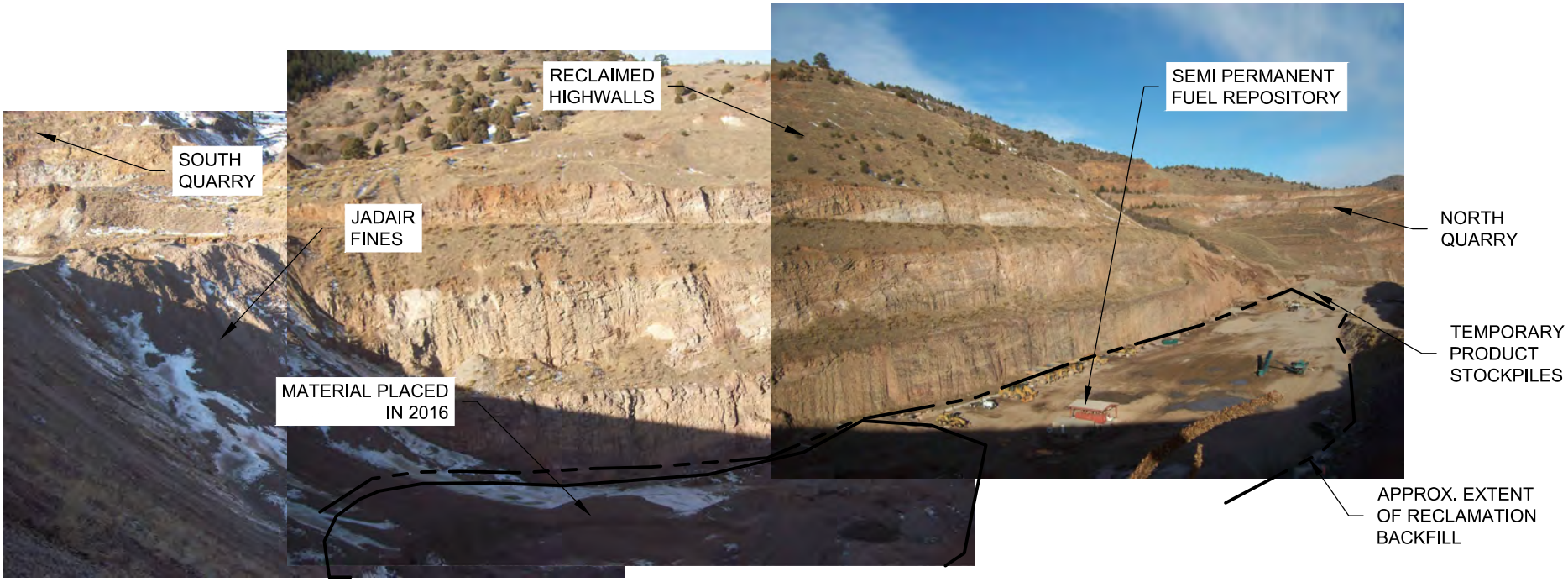
Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	SITE LOCATION MAP
Aggregate Industries	Project 1705051	December 2019 Figure 1

P:\1800091 - 2017 Morrison Quarry\00 CAD\Figures\ 2019 Annual Report\ Figure 1 - Site Location Map.dwg Dec 2019



NOTES:
1. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	CURRENT CONFIGURATION OF NORTH QUARRY
Aggregate Industries	Project 1705051	December 2019 Figure 2



NOTES:

1. MATERIAL PLACED IN 2016 VIA SLURRY UP TO FINAL RECLAMATION GRADE, EL. 6500. JADAIR FINES STOCKPILED FOR FUTURE USE IN RECLAMATION SLOPES
2. DRAWING NOT TO SCALE.

Morrison Quarry 2018 Annual Report
DRMS Permit M-1973-021

Aggregate Industries

GEI Consultants

CURRENT CONFIGURATION OF CENTRAL QUARRY

Project 1705051 | December 2019 | Figure 3

NOTES:

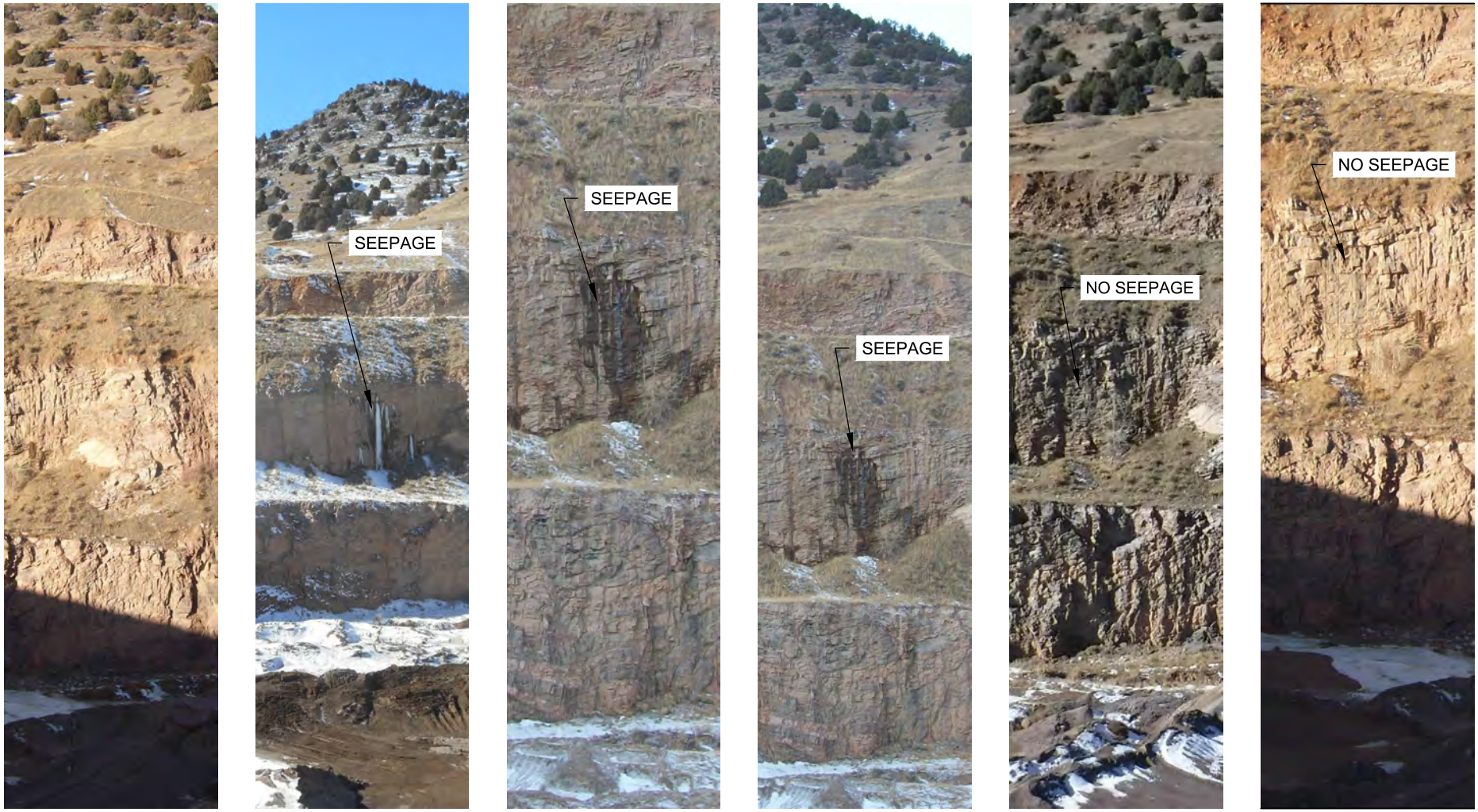
1. DATE OF TOPOGRAPHY OCTOBER 2017 AND NOVEMBER 2018.
2. IMAGERY TAKEN BY AGGREGATE INDUSTRIES ON AUGUST 4, 2018.
3. AREAS RECLAIMED BASED ON UAS PHOTOS DUE TO INACCESSIBILITY.
4. SCANLINE STATIONING IS APPROXIMATE, AND ESTIMATED BASED ON SITE RECONNAISSANCE.

0 400 800

SCALE, FEET

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	SOUTH QUARRY CONFIGURATION AND HIGHWALL SCANLINES
Aggregate Industries	Project 1705051	December 2019 Figure 4

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 4 - Current Configuation of the South Quarry.dwg Dec 2019



NOTES:
1. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	CENTRAL QUARRY SEEPAGE COMPARISON 2014 - 2018
Aggregate Industries	Project 1705051	December 2019 Figure 5

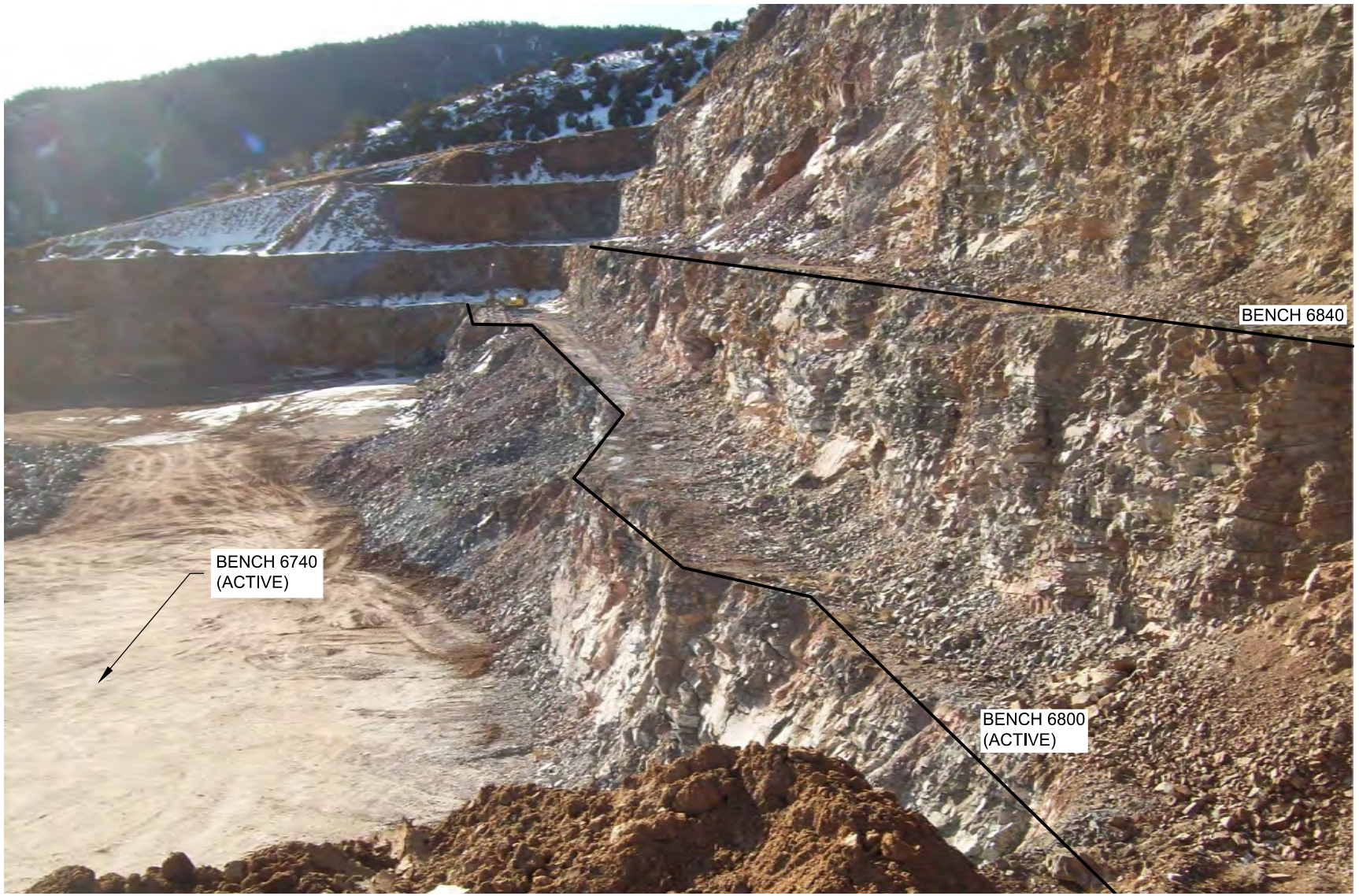
SOUTH QUARRY MONITORING WELL

MW-2019-03

NOTES:

1. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	CENTRAL QUARRY MONITORING WELL
Aggregate Industries	Project 1705051	December 2019 Figure 6



NOTES:

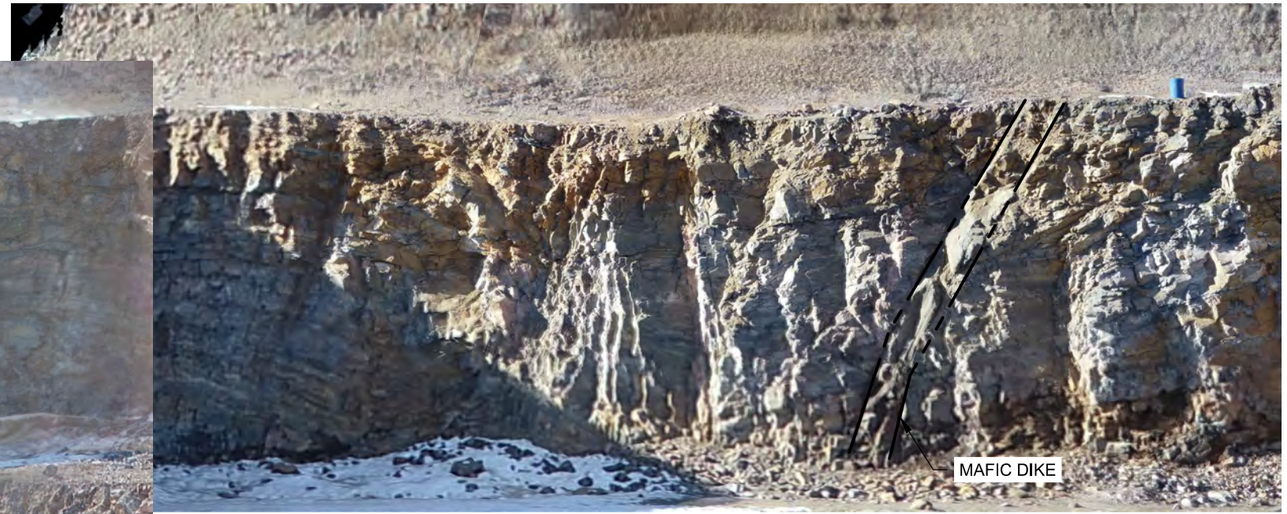
1. DRAWING NOT TO SCALE.
2. IMAGE IS FACING ROUGHLY SOUTH.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	SOUTH QUARRY HIGHWALL ORTHOPLANES ABOVE EL. 6740
Aggregate Industries	Project 1705051	December 2019 Figure 7

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 7 - South Quarry Orthoplanes Above El. 6740.dwg Dec 2019

NOTES:
1. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	SOUTH QUARRY RECLAMATION
Aggregate Industries	Project 1705051	December 2019 Figure 8

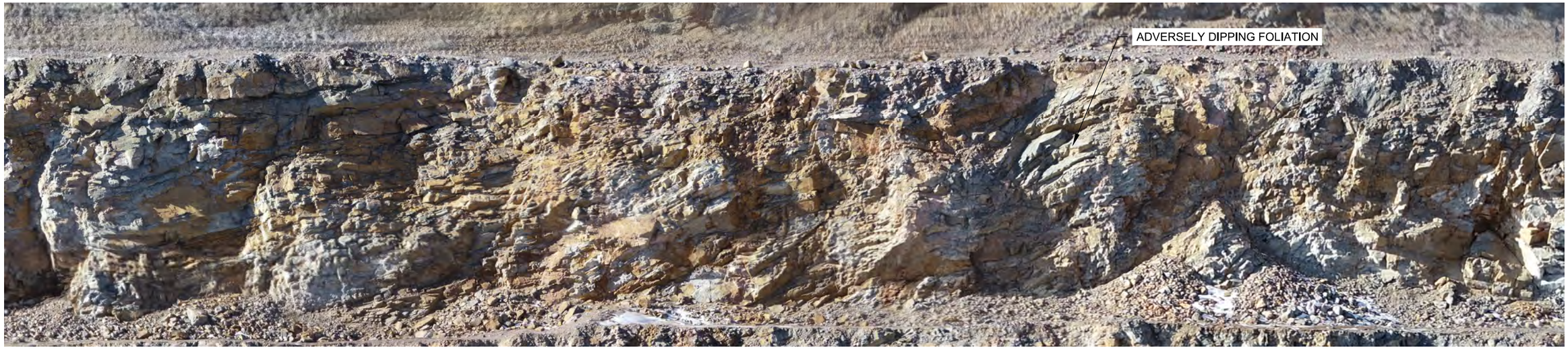


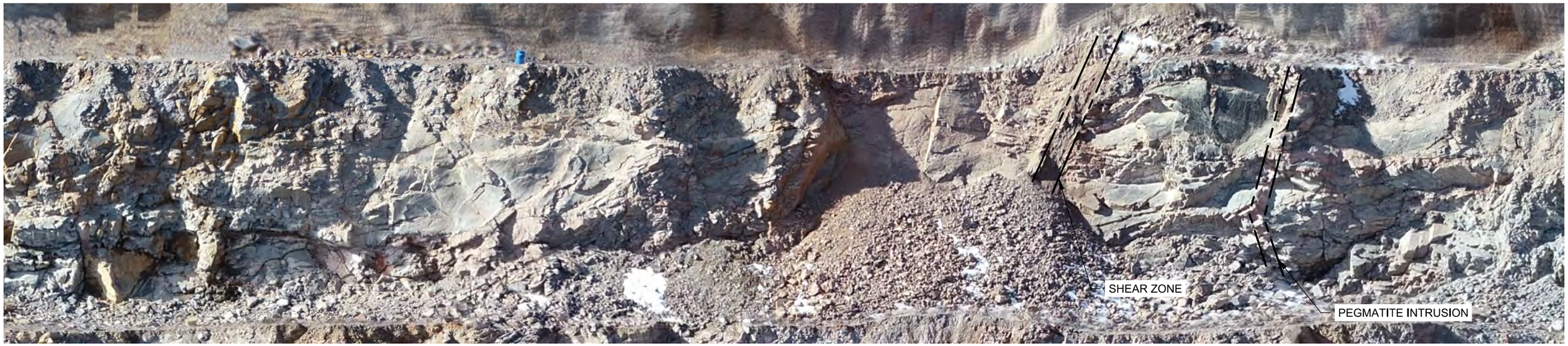
NOTES:

1. BENCH WAS INACCESSIBLE DURING INSPECTION. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON DECEMBER 12, 2019 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE. THE LEFT END OF THE HIGHWALL IS NOT VISIBLE DUE TO BLASTING DEBRIS.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6840 (1 OF 3)
Aggregate Industries	Project 1705051	December 2019 Figure 9

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 9 - Bench 6840 (1 of 3).dwg Dec 2019





NOTES:

1. BENCH WAS INACCESSIBLE DURING INSPECTION. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON DECEMBER 12, 2019 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6840 (2 OF 3)
Aggregate Industries	Project 1705051	December 2019 Figure 10

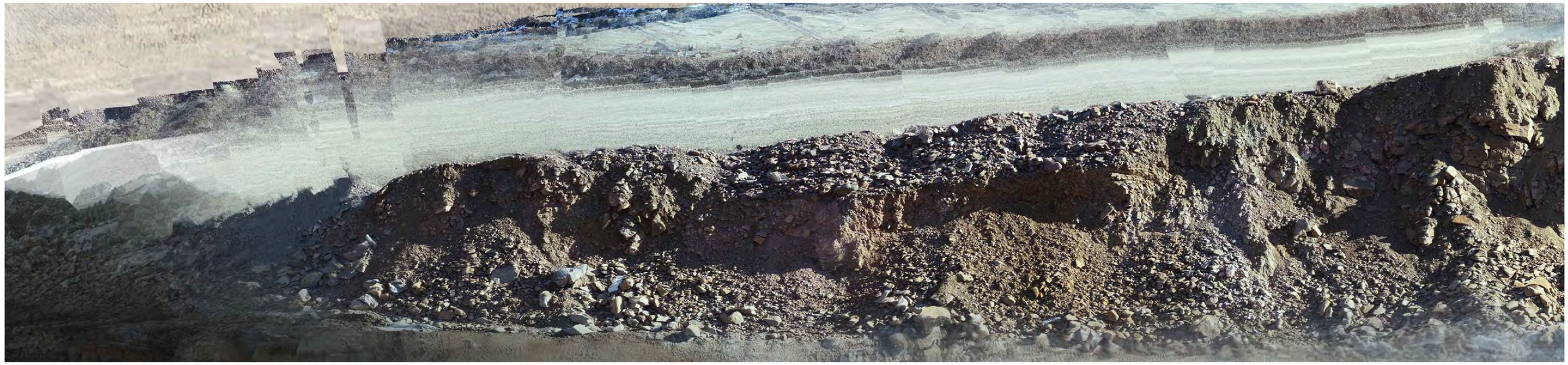
P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 10 - Bench 6840 (2 of 3).dwg Dec 2019

NOTES:

1. BENCH WAS INACCESSIBLE DURING INSPECTION. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON DECEMBER 12, 2019 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE. RIGHT END OF HIGHWALL EXCAVATED INTO OVERBURDEN.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6840 (3 OF 3)
Aggregate Industries	Project 1705051	December 2019 Figure 11

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 11 - Bench 6840 (3 of 3).dwg Dec 2019



NOTES:

1. BENCH WAS INACCESSIBLE DURING INSPECTION. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON NOVEMBER 29, 2018 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.

2. DRAWING NOT TO SCALE. LEFT END OF HIGHWALL OBSCURED BY DEBRIS.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6800 (1 OF 5)
Aggregate Industries	Project 1705051	December 2019 Figure 12

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 12 - Bench 6800 (1 of 5).dwg Dec 2019

NOTES:

1. BENCH WAS INACCESSIBLE DURING INSPECTION. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON NOVEMBER 29, 2018 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6800 (2 OF 5)
Aggregate Industries	Project 1705051	December 2019 Figure 13

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 13 - Bench 6800 (2 of 5).dwg Dec 2019

NOTES:

1. BENCH WAS INACCESSIBLE DURING INSPECTION. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON NOVEMBER 29, 2018 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6800 (3 OF 5)
Aggregate Industries	Project 1705051	December 2019 Figure 14

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 14 - Bench 6800 (3 of 5).dwg Dec 2019

NOTES:

1. BENCH WAS INACCESSIBLE DURING INSPECTION. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON NOVEMBER 29, 2018 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6800 (4 OF 5)
Aggregate Industries	Project 1705051	December 2019 Figure 15

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 15 - Bench 6800 (4 of 5).dwg Dec 2019

NOTES:

1. BENCH WAS INACCESSIBLE DURING INSPECTION. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON NOVEMBER 29, 2018 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE. RIGHT END OF HIGHWALL OBSCURED BY OVERBURDEN AND DEBRIS.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6800 (5 OF 5)
Aggregate Industries	Project 1705051	December 2019 Figure 16

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 16 - Bench 6800 (5 of 5).dwg Dec 2019

0+00

3+00

NOTES:

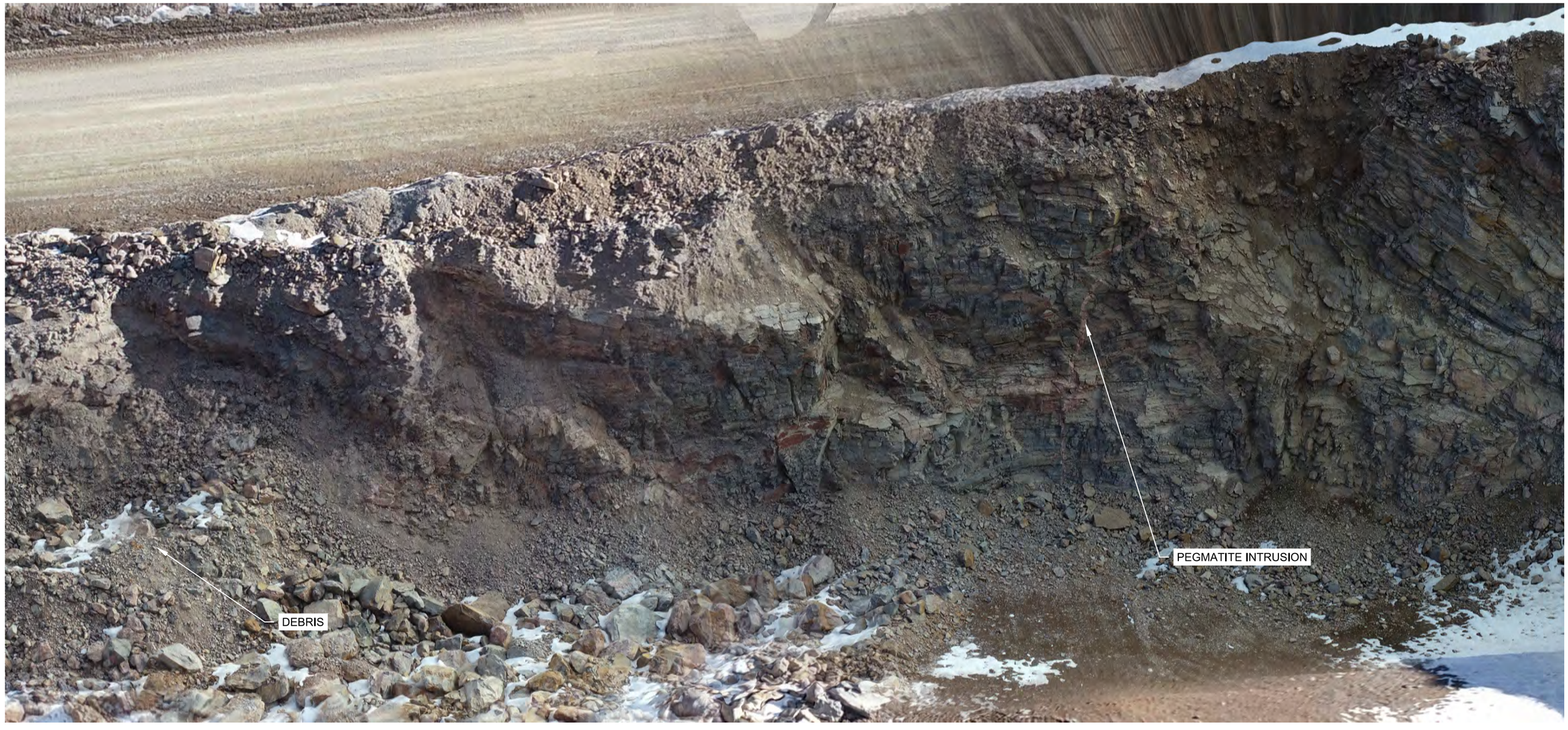
1. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON DECEMBER 12, 2019 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE. SCANLINE A OBSCURED BY DEBRIS.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6740 SCANLINE A
Aggregate Industries	Project 1705051	December 2019 Figure 17

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 17 - Bench 6740 Scanline A.dwg Dec 2019

3+00

4+00



NOTES:

1. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON DECEMBER 12, 2019 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6740 SCANLINE B
Aggregate Industries	Project 1705051	December 2019 Figure 18

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 18 - Bench 6740 Scanline B.dwg Dec 2019

4+00

4+75

NOTES:

1. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON DECEMBER 12, 2019 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6740 SCANLINE C
Aggregate Industries	Project 1705051	December 2019 Figure 19

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 19 - Bench 6740 Scanline C.dwg Dec 2019

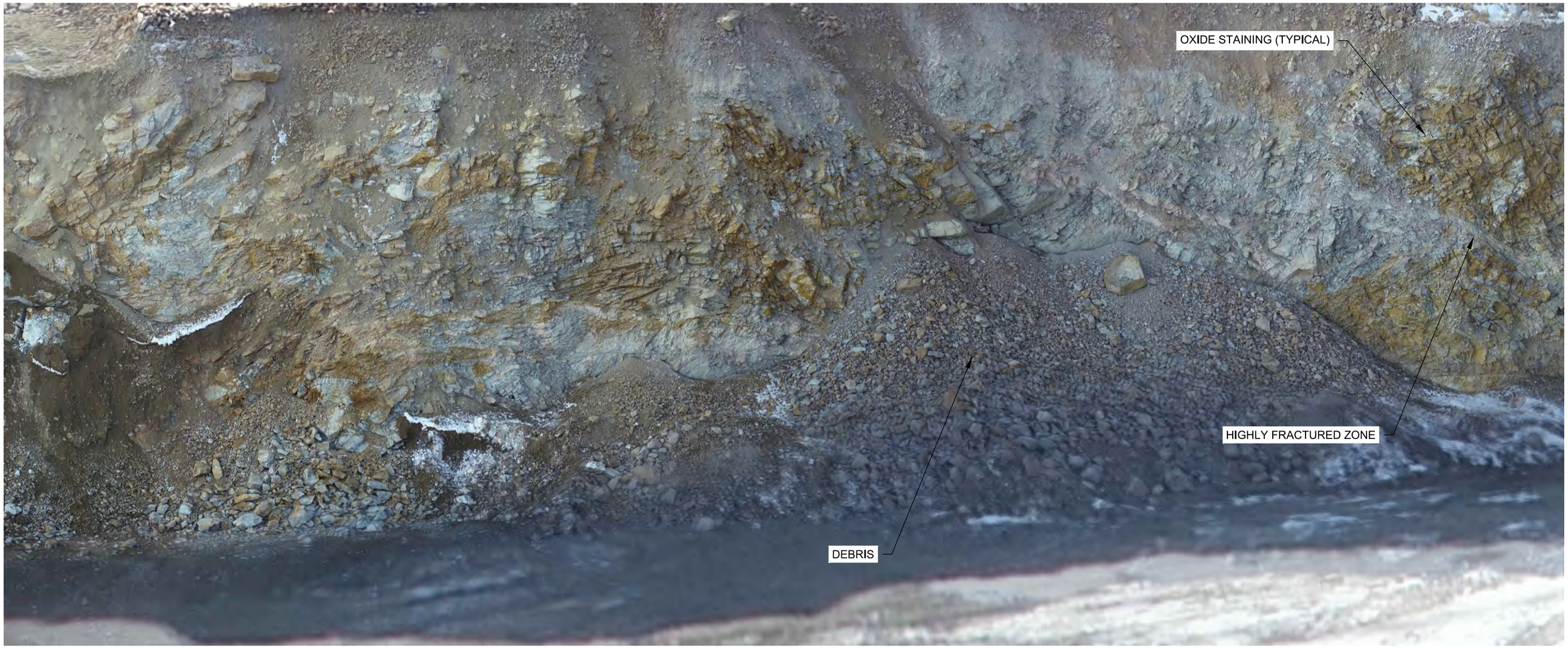
4+75

6+50

NOTES:

1. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON DECEMBER 12, 2019 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6740 SCANLINE D
Aggregate Industries	Project 1705051	December 2019 Figure 20



NOTES:

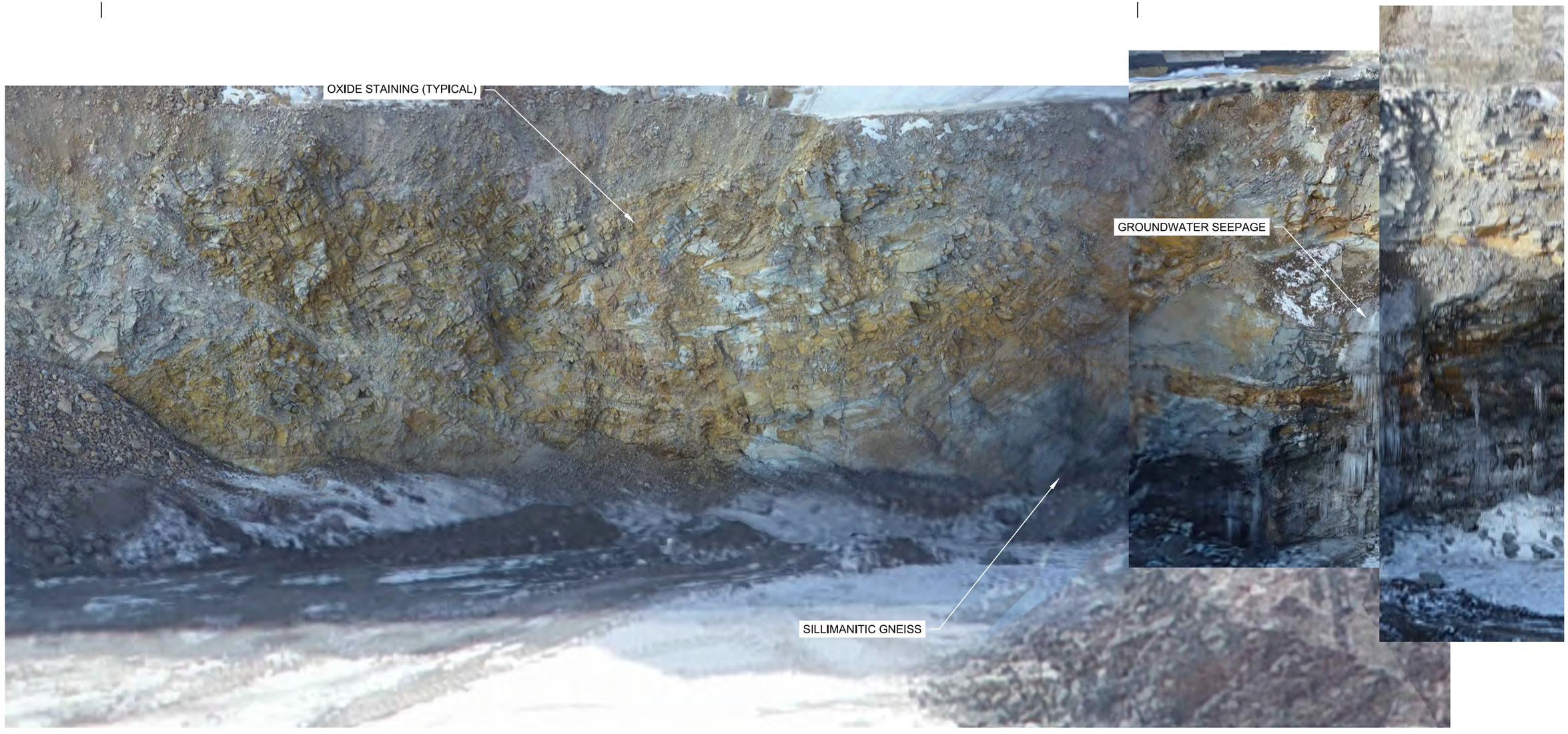
1. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON DECEMBER 12, 2019 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6740 SCANLINE E
Aggregate Industries	Project 1705051	December 2019 Figure 21

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 21 - Bench 6740 Scanline E.dwg Dec 2019

8+00

9+00



NOTES:

1. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON DECEMBER 12, 2019 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6740 SCANLINE F
Aggregate Industries	Project 1705051	December 2019 Figure 22

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 22 - Bench 6740 Scanline F.dwg Dec 2019

9+00

10+50

NOTES:

1. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON DECEMBER 12, 2019 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6740 SCANLINE G
Aggregate Industries	Project 1705051	December 2019 Figure 23

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 23 - Bench 6740 Scanline G.dwg Dec 2019

10+50

12+40

SCANLINE H

PROFILE 1

12+40

15+25

SCANLINE H

PROFILE 2

NOTES:

1. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON DECEMBER 12, 2019 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6740 SCANLINE H
Aggregate Industries	Project 1705051	December 2019 Figure 24

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 24 - Bench 6740 Scanline H.dwg Dec 2019

15+25

18+00

NOTES:

1. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON DECEMBER 12, 2019 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6740 SCANLINE I
Aggregate Industries	Project 1705051	December 2019 Figure 25

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 25 - Bench 6740 Scanline I.dwg Dec 2019

18+00

18+75

NOTES:

1. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON DECEMBER 12, 2019 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6740 SCANLINE J
Aggregate Industries	Project 1705051	December 2019 Figure 26

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 26 - Bench 6740 Scanline J.dwg Dec 2019

18+75

20+00

NOTES:

1. IMAGERY OBTAINED USING UNMANNED AERIAL SYSTEM ON DECEMBER 12, 2019 AND PROCESSED INTO PHOTOMOSAICS USING PIX4D SOFTWARE.
2. DRAWING NOT TO SCALE. SCANLINE K OBSCURED BY OVERBURDEN AND DEBRIS.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	BENCH 6740 SCANLINE K
Aggregate Industries	Project 1705051	December 2019 Figure 27

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 27 - Bench 6740 Scanline K.dwg Dec 2019

SOUTH QUARRY MONITORING WELL
MW-2019-01

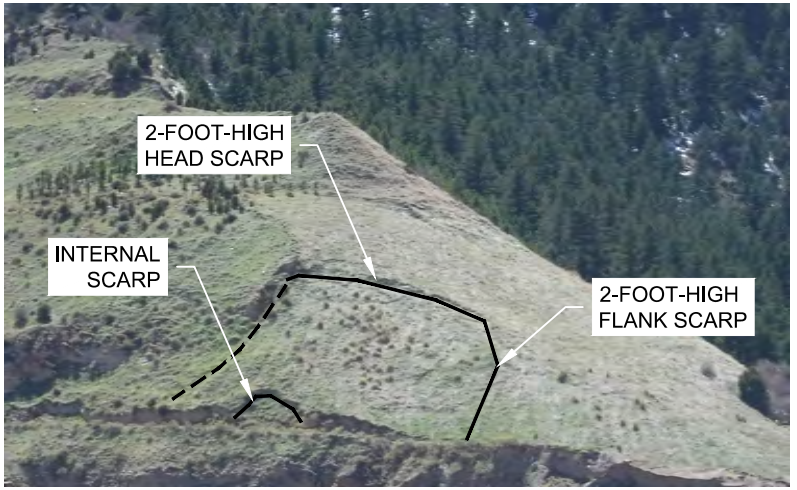
SOUTH QUARRY MONITORING WELL
MW-2019-02

NOTES:
1. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report DRMS Permit M-1973-021	GEI Consultants	SOUTH QUARRY MONITORING WELL
Aggregate Industries	Project 1705051	December 2019 Figure 28

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 28 - South Quarry Monitoring Well.dwg Dec 2019

2018



2018

2019

2019

NOTES:
1. 2018 PHOTOS TAKEN IN JUNE 2018. 2019 PHOTOS TAKEN DURING ANNUAL INSPECTION.
2. DRAWING NOT TO SCALE.

Morrison Quarry 2019 Annual Report
DRMS Permit M-1973-021

Aggregate Industries

GEI Consultants

CENTRAL QUARRY INSTABILITY

Project 1705051 | December 2019 | Figure 29

P:\1800091 - 2017 Morrison Quarry\00_CAD\Figures_2019 Annual Report\ Figure 29 - Central Quarry Instability.dwg Dec 2019

Appendix A RMR Data

APPENDIX A:

South Quarry of Morrison Quarry, Bench 6740, Scanline B, 3+00 - 4+00

Strike and Dip Orientations:							
	Average Strike	Average Dip	Direction	Strike from	Strike to	Dip from	Dip to
Set 1 (Primary 1)	15	73	NE	10	30	55	90
Set 2 (Primary 2)	292	82	WNW	230	330	65	90
Set 3 (Secondary 1)							
Set 4 (Secondary 2)							
Set 5 (Foliation)	100	15	ESE	100	100	12	18

Estimated Strength of Intact Rock Material:		
Designation:	Compressive Strength Range	Estimated in Field
Very High (15)	>250 Mpa (>36,260 psi)	
High (12)	100-250 Mpa (14,500-36,260 psi)	X
Medium High (7)	50-100 Mpa (7,250-14,500 psi)	X
Moderate (4)	25-50 Mpa (3,625-7,250 psi)	
Low (2)	5-25 Mpa (725-3,625 psi)	
Very Low (1)	1-5 Mpa (145-725 psi)	

Estimated Drill Core Quality (RQD)		
Designation:	RQD Percentage Range	Estimated in Field
Excellent Quality (20)	90-100%	
Good Quality (17)	75-90%	
Fair Quality (13)	50-75%	
Poor Quality (8)	25-50%	X
Very Poor Quality (3)	<25%	

Spacing of Discontinuities						
		Set 1	Set 2	Set 3	Set 4	Set 5
Very Wide (20)	>2m (>6.5 ft)					
Wide (15)	0.6 - 2 m (2 - 6.5 ft)	X	X			
Moderate (10)	200-600 mm (8 - 24 in)	X	X			X
Close (8)	60-200 mm (2.4 - 8 in)					X
Very Close (5)	<60mm (<2.4 in)					

Discontinuity Persistence							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Low (6)	<1m (<3.3 ft)						Notes:
Low (4)	1 - 3 m (3.3 - 9.9 ft)	X	X				
Medium (2)	3 - 10 m (9.9 - 33 ft)	X					
High (1)	10 - 20 m (33 - 66 ft)						
Very High (0)	>20 m (>66 ft)					X	

Discontinuity Separation (Aperture)						
		Set 1	Set 2	Set 3	Set 4	Set 5
Very Tight Joints (6)	<0.1 mm (< 0.003 in)					
Tight Joints (5)	0.1 - 0.5 mm (0.003 - 0.02 in)					
Moderately Open Joints (4)	0.5 - 2.5 mm (0.02 - 0.1 in)	X	X			X
Open Joints (1)	2.5 - 10 mm (0.1 - 0.4 in)	X	X			
Very Wide Aperture (0)	>10 mm (> 0.4 in)					

Discontinuity Roughness							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Rough Surfaces (6)	VR	X					Notes:
Rough Surfaces (5)	R	X	X				
Slightly Rough Surfaces (3)	SR	X				X	
Smooth Surfaces (1)	SM	X				X	
Slickensided Surfaces (0)	SL						

Discontinuity Wall Face Weathering						
		Set 1	Set 2	Set 3	Set 4	Set 5
Unweathered (6)	UW					
Slightly Weathered (5)	SW	X	X			X
Moderately Weathered (3)	MW		X			
Highly Weathered (1)	HW					
Completely Weathered (0)	CW					
Residual Soil (0)	RS					

RMR Classification:	29 - Poor	to	54 - Fair

Additional Notes:	Uncontrolled blasting evident; Primary Set 1 has a smooth face, but is jagged overall
Groundwater conditions	
Discontinuity filling, staining	
Highwall trend, etc.	

APPENDIX A:

South Quarry of Morrison Quarry, Bench 6740, Scanline C, 4+00 - 7+75

Strike and Dip Orientations:							
	Average Strike	Average Dip	Direction	Strike from	Strike to	Dip from	Dip to
Set 1 (Primary 1)	181	81		175	190	80	85
Set 2 (Primary 2)	101	76		85	150	50	90
Set 3 (Secondary 1)							
Set 4 (Secondary 2)							
Set 5 (Foliation)	186	39		40	325	32	45

Estimated Strength of Intact Rock Material:		
Designation:	Compressive Strength Range	Estimated in Field
Very High (15)	>250 Mpa (>36,260 psi)	
High (12)	100-250 Mpa (14,500-36,260 psi)	X
Medium High (7)	50-100 Mpa (7,250-14,500 psi)	X
Moderate (4)	25-50 Mpa (3,625-7,250 psi)	
Low (2)	5-25 Mpa (725-3,625 psi)	
Very Low (1)	1-5 Mpa (145-725 psi)	

Estimated Drill Core Quality (RQD)		
Designation:	RQD Percentage Range	Estimated in Field
Excellent Quality (20)	90-100%	
Good Quality (17)	75-90%	
Fair Quality (13)	50-75%	X
Poor Quality (8)	25-50%	X
Very Poor Quality (3)	<25%	

Spacing of Discontinuities						
		Set 1	Set 2	Set 3	Set 4	Set 5
Very Wide (20)	>2m (>6.5 ft)					
Wide (15)	0.6 - 2 m (2 - 6.5 ft)	X	X			X
Moderate (10)	200-600 mm (8 - 24 in)	X				X
Close (8)	60-200 mm (2.4 - 8 in)					X
Very Close (5)	<60mm (<2.4 in)					

Discontinuity Persistence							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Low (6)	<1m (<3.3 ft)						Notes:
Low (4)	1 - 3 m (3.3 - 9.9 ft)						
Medium (2)	3 - 10 m (9.9 - 33 ft)	X	X				
High (1)	10 - 20 m (33 - 66 ft)		X			X	
Very High (0)	>20 m (>66 ft)					X	

Discontinuity Separation (Aperture)						
		Set 1	Set 2	Set 3	Set 4	Set 5
Very Tight Joints (6)	<0.1 mm (< 0.003 in)	X				
Tight Joints (5)	0.1 - 0.5 mm (0.003 - 0.02 in)	X	X			X
Moderately Open Joints (4)	0.5 - 2.5 mm (0.02 - 0.1 in)		X			X
Open Joints (1)	2.5 - 10 mm (0.1 - 0.4 in)		X			X
Very Wide Aperture (0)	>10 mm (> 0.4 in)					

Discontinuity Roughness							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Rough Surfaces (6)	VR	X					Notes:
Rough Surfaces (5)	R	X	X				
Slightly Rough Surfaces (3)	SR		X				
Smooth Surfaces (1)	SM					X	
Slickensided Surfaces (0)	SL						

Discontinuity Wall Face Weathering						
		Set 1	Set 2	Set 3	Set 4	Set 5
Unweathered (6)	UW	X				X
Slightly Weathered (5)	SW	X	X			
Moderately Weathered (3)	MW		X			
Highly Weathered (1)	HW					
Completely Weathered (0)	CW					
Residual Soil (0)	RS					

RMR Classification:	28 - Poor	to	58 - Fair

Additional Notes: *Groundwater conditions* *Discontinuity filling, staining* *Highwall trend, etc.*	Uncontrolled blasting resulted in disturbed face with variable joint conditions; Iron oxide staining in upper 5-10 feet; Joint set 1 more weathered at top than at bottom;

APPENDIX A:

South Quarry of Morrison Quarry, Bench 6740, Scanline D, 4+75 - 6+50

Strike and Dip Orientations:							
	Average Strike	Average Dip	Direction	Strike from	Strike to	Dip from	Dip to
Set 1 (Primary 1)	143	70	SE	60	330	57	90
Set 2 (Primary 2)	280	70	W	275	290	50	78
Set 3 (Secondary 1)							
Set 4 (Secondary 2)							
Set 5 (Foliation)	106	22	E	80	124	8	35

Estimated Strength of Intact Rock Material:		
Designation:	Compressive Strength Range	Estimated in Field
Very High (15)	>250 Mpa (>36,260 psi)	
High (12)	100-250 Mpa (14,500-36,260 psi)	X
Medium High (7)	50-100 Mpa (7,250-14,500 psi)	X
Moderate (4)	25-50 Mpa (3,625-7,250 psi)	
Low (2)	5-25 Mpa (725-3,625 psi)	
Very Low (1)	1-5 Mpa (145-725 psi)	

Estimated Drill Core Quality (RQD)		
Designation:	RQD Percentage Range	Estimated in Field
Excellent Quality (20)	90-100%	
Good Quality (17)	75-90%	
Fair Quality (13)	50-75%	
Poor Quality (8)	25-50%	
Very Poor Quality (3)	<25%	X

Spacing of Discontinuities						
		Set 1	Set 2	Set 3	Set 4	Set 5
Very Wide (20)	>2m (>6.5 ft)					
Wide (15)	0.6 - 2 m (2 - 6.5 ft)	X				
Moderate (10)	200-600 mm (8 - 24 in)		X			
Close (8)	60-200 mm (2.4 - 8 in)		X			
Very Close (5)	<60mm (<2.4 in)					X

Discontinuity Persistence							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Low (6)	<1m (<3.3 ft)		X				Notes:
Low (4)	1 - 3 m (3.3 - 9.9 ft)		X				
Medium (2)	3 - 10 m (9.9 - 33 ft)	X	X				
High (1)	10 - 20 m (33 - 66 ft)					X	
Very High (0)	>20 m (>66 ft)					X	

Discontinuity Separation (Aperture)						
		Set 1	Set 2	Set 3	Set 4	Set 5
Very Tight Joints (6)	<0.1 mm (< 0.003 in)					
Tight Joints (5)	0.1 - 0.5 mm (0.003 - 0.02 in)	X				X
Moderately Open Joints (4)	0.5 - 2.5 mm (0.02 - 0.1 in)	X	X			X
Open Joints (1)	2.5 - 10 mm (0.1 - 0.4 in)		X			
Very Wide Aperture (0)	>10 mm (> 0.4 in)					

Discontinuity Roughness							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Rough Surfaces (6)	VR						Notes:
Rough Surfaces (5)	R	X					
Slightly Rough Surfaces (3)	SR	X	X				
Smooth Surfaces (1)	SM	X				X	
Slickensided Surfaces (0)	SL						

Discontinuity Wall Face Weathering						
		Set 1	Set 2	Set 3	Set 4	Set 5
Unweathered (6)	UW					
Slightly Weathered (5)	SW					
Moderately Weathered (3)	MW	X	X			X
Highly Weathered (1)	HW					
Completely Weathered (0)	CW					
Residual Soil (0)	RS					

RMR Classification:	20 - Very Poor	to	49 - Fair

Additional Notes:	Station 5+50 - 6+00 drilling dust present, no visible rock; entire scanline unmappable on lower half due to debris; uncontrolled blasting evident; large areas of oxide staining
Groundwater conditions	
Discontinuity filling, staining	
Highwall trend, etc.	

APPENDIX A:

South Quarry of Morrison Quarry, Bench 6740, Scanline E, 6+50 - 8+00

Strike and Dip Orientations:							
	Average Strike	Average Dip	Direction	Strike from	Strike to	Dip from	Dip to
Set 1 (Primary 1)	196	64	S	175	225	55	80
Set 2 (Primary 2)	259	53	WSW	105	347	35	72
Set 3 (Secondary 1)							
Set 4 (Secondary 2)							
Set 5 (Foliation)	112	29	ESE	102	125	17	36

Estimated Strength of Intact Rock Material:		
Designation:	Compressive Strength Range	Estimated in Field
Very High (15)	>250 Mpa (>36,260 psi)	
High (12)	100-250 Mpa (14,500-36,260 psi)	X
Medium High (7)	50-100 Mpa (7,250-14,500 psi)	X
Moderate (4)	25-50 Mpa (3,625-7,250 psi)	
Low (2)	5-25 Mpa (725-3,625 psi)	
Very Low (1)	1-5 Mpa (145-725 psi)	

Estimated Drill Core Quality (RQD)		
Designation:	RQD Percentage Range	Estimated in Field
Excellent Quality (20)	90-100%	
Good Quality (17)	75-90%	
Fair Quality (13)	50-75%	
Poor Quality (8)	25-50%	
Very Poor Quality (3)	<25%	X

Spacing of Discontinuities						
		Set 1	Set 2	Set 3	Set 4	Set 5
Very Wide (20)	>2m (>6.5 ft)					
Wide (15)	0.6 - 2 m (2 - 6.5 ft)		X			
Moderate (10)	200-600 mm (8 - 24 in)	X	X			
Close (8)	60-200 mm (2.4 - 8 in)	X				X
Very Close (5)	<60mm (<2.4 in)					X

Discontinuity Persistence							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Low (6)	<1m (<3.3 ft)		X				Notes:
Low (4)	1 - 3 m (3.3 - 9.9 ft)	X				X	
Medium (2)	3 - 10 m (9.9 - 33 ft)					X	
High (1)	10 - 20 m (33 - 66 ft)						
Very High (0)	>20 m (>66 ft)						

Discontinuity Separation (Aperture)						
		Set 1	Set 2	Set 3	Set 4	Set 5
Very Tight Joints (6)	<0.1 mm (< 0.003 in)					
Tight Joints (5)	0.1 - 0.5 mm (0.003 - 0.02 in)					X
Moderately Open Joints (4)	0.5 - 2.5 mm (0.02 - 0.1 in)	X	X			
Open Joints (1)	2.5 - 10 mm (0.1 - 0.4 in)	X	X			
Very Wide Aperture (0)	>10 mm (> 0.4 in)					

Discontinuity Roughness							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Rough Surfaces (6)	VR						Notes:
Rough Surfaces (5)	R	X					
Slightly Rough Surfaces (3)	SR	X	X			X	
Smooth Surfaces (1)	SM	X	X			X	
Slickensided Surfaces (0)	SL						

Discontinuity Wall Face Weathering						
		Set 1	Set 2	Set 3	Set 4	Set 5
Unweathered (6)	UW					
Slightly Weathered (5)	SW	X	X			X
Moderately Weathered (3)	MW	X	X			
Highly Weathered (1)	HW					
Completely Weathered (0)	CW					
Residual Soil (0)	RS					

RMR Classification:	22 - Poor	to	51 - Fair

Additional Notes:	Primary Set 2 aperture is difficult to examine; where observed, the foliations are tight, but in general the rock here is more massive with less foliations than previously observed in other highwalls
Groundwater conditions	
Discontinuity filling, staining	
Highwall trend, etc.	

APPENDIX A:

South Quarry of Morrison Quarry, Bench 6740, Scanline F, 8+00 - 9+00

Strike and Dip Orientations:							
	Average Strike	Average Dip	Direction	Strike from	Strike to	Dip from	Dip to
Set 1 (Primary 1)	176	56	S	166	182	39	67
Set 2 (Primary 2)	296	76	WNW	291	307	61	82
Set 3 (Secondary 1)							
Set 4 (Secondary 2)							
Set 5 (Foliation)	62	18	ENE	13	134	12	27

Estimated Strength of Intact Rock Material:		
Designation:	Compressive Strength Range	Estimated in Field
Very High (15)	>250 Mpa (>36,260 psi)	
High (12)	100-250 Mpa (14,500-36,260 psi)	X
Medium High (7)	50-100 Mpa (7,250-14,500 psi)	X
Moderate (4)	25-50 Mpa (3,625-7,250 psi)	
Low (2)	5-25 Mpa (725-3,625 psi)	
Very Low (1)	1-5 Mpa (145-725 psi)	

Estimated Drill Core Quality (RQD)		
Designation:	RQD Percentage Range	Estimated in Field
Excellent Quality (20)	90-100%	
Good Quality (17)	75-90%	
Fair Quality (13)	50-75%	
Poor Quality (8)	25-50%	X
Very Poor Quality (3)	<25%	X

Spacing of Discontinuities						
		Set 1	Set 2	Set 3	Set 4	Set 5
Very Wide (20)	>2m (>6.5 ft)					
Wide (15)	0.6 - 2 m (2 - 6.5 ft)					X
Moderate (10)	200-600 mm (8 - 24 in)	X	X			X
Close (8)	60-200 mm (2.4 - 8 in)	X	X			X
Very Close (5)	<60mm (<2.4 in)					

Discontinuity Persistence							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Low (6)	<1m (<3.3 ft)						Notes:
Low (4)	1 - 3 m (3.3 - 9.9 ft)	X					
Medium (2)	3 - 10 m (9.9 - 33 ft)	X	X			X	
High (1)	10 - 20 m (33 - 66 ft)			X			
Very High (0)	>20 m (>66 ft)						

Discontinuity Separation (Aperture)							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Tight Joints (6)	<0.1 mm (< 0.003 in)						
Tight Joints (5)	0.1 - 0.5 mm (0.003 - 0.02 in)			X		X	
Moderately Open Joints (4)	0.5 - 2.5 mm (0.02 - 0.1 in)	X	X	X		X	
Open Joints (1)	2.5 - 10 mm (0.1 - 0.4 in)	X	X			X	
Very Wide Aperture (0)	>10 mm (> 0.4 in)						

Discontinuity Roughness							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Rough Surfaces (6)	VR						Notes:
Rough Surfaces (5)	R						
Slightly Rough Surfaces (3)	SR	X	X				
Smooth Surfaces (1)	SM	X	X			X	
Slickensided Surfaces (0)	SL						

Discontinuity Wall Face Weathering							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Unweathered (6)	UW						
Slightly Weathered (5)	SW					X	
Moderately Weathered (3)	MW	X	X	X		X	
Highly Weathered (1)	HW						
Completely Weathered (0)	CW						
Residual Soil (0)	RS						

RMR Classification:	24 - Poor	to	52 - Fair

Additional Notes: *Groundwater conditions* *Discontinuity filling, staining* *Highwall trend, etc.*	Note that the mafic dike is not visible on this bench, but is observed above in location; there is sillimanitic gneiss present at the base of the highwall; foliations are generally smooth, but there are some locations showing overturned or wavy foliations; Secondary Set 1 (Joint Set 3) is a mapped shear zone in the highwall

APPENDIX A:

South Quarry of Morrison Quarry, Bench 6740, Scanline G, 9+00 - 15+25

Strike and Dip Orientations:							
	Average Strike	Average Dip	Direction	Strike from	Strike to	Dip from	Dip to
Set 1 (Primary 1)	99	58	E	5	188	36	87
Set 2 (Primary 2)	226	76	SW	60	294	62	84
Set 3 (Secondary 1)							
Set 4 (Secondary 2)							
Set 5 (Foliation)	106	52	ESE	0	347	4	90

Estimated Strength of Intact Rock Material:		
Designation:	Compressive Strength Range	Estimated in Field
Very High (15)	>250 Mpa (>36,260 psi)	
High (12)	100-250 Mpa (14,500-36,260 psi)	X
Medium High (7)	50-100 Mpa (7,250-14,500 psi)	X
Moderate (4)	25-50 Mpa (3,625-7,250 psi)	X
Low (2)	5-25 Mpa (725-3,625 psi)	
Very Low (1)	1-5 Mpa (145-725 psi)	

Estimated Drill Core Quality (RQD)		
Designation:	RQD Percentage Range	Estimated in Field
Excellent Quality (20)	90-100%	
Good Quality (17)	75-90%	
Fair Quality (13)	50-75%	
Poor Quality (8)	25-50%	X
Very Poor Quality (3)	<25%	

Spacing of Discontinuities						
		Set 1	Set 2	Set 3	Set 4	Set 5
Very Wide (20)	>2m (>6.5 ft)					
Wide (15)	0.6 - 2 m (2 - 6.5 ft)	X	X			
Moderate (10)	200-600 mm (8 - 24 in)	X	X			X
Close (8)	60-200 mm (2.4 - 8 in)		X			X
Very Close (5)	<60mm (<2.4 in)					

Discontinuity Persistence							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Low (6)	<1m (<3.3 ft)						Notes:
Low (4)	1 - 3 m (3.3 - 9.9 ft)	X	X				
Medium (2)	3 - 10 m (9.9 - 33 ft)	X					
High (1)	10 - 20 m (33 - 66 ft)						
Very High (0)	>20 m (>66 ft)					X	

Discontinuity Separation (Aperture)							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Tight Joints (6)	<0.1 mm (< 0.003 in)						
Tight Joints (5)	0.1 - 0.5 mm (0.003 - 0.02 in)					X	
Moderately Open Joints (4)	0.5 - 2.5 mm (0.02 - 0.1 in)		X				
Open Joints (1)	2.5 - 10 mm (0.1 - 0.4 in)	X	X				
Very Wide Aperture (0)	>10 mm (> 0.4 in)						

Discontinuity Roughness							
		Set 1	Set 2	Set 3	Set 4	Set 5	Notes:
Very Rough Surfaces (6)	VR						
Rough Surfaces (5)	R	X	X				
Slightly Rough Surfaces (3)	SR						
Smooth Surfaces (1)	SM						
Slickensided Surfaces (0)	SL					X	Wavy

Discontinuity Wall Face Weathering							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Unweathered (6)	UW						
Slightly Weathered (5)	SW	X	X			X	
Moderately Weathered (3)	MW						
Highly Weathered (1)	HW						
Completely Weathered (0)	CW						
Residual Soil (0)	RS						

RMR Classification:	26 - Poor	to	54 - Fair

Additional Notes: *Groundwater conditions* *Discontinuity filling, staining* *Highwall trend, etc.*	Sillimanitic gneiss in corner at Sta. 9+00; mafic region with groundwater 9+00 - 9+30, highly variable foliations with large dip at about Sta. 10+00; pegmatite at Sta. 10+00 - 10+20, 4 to 6 feet wide, cross cuts the foliation

APPENDIX A:

South Quarry of Morrison Quarry, Bench 6740, Scanline H, 10+50 - 15+25

Strike and Dip Orientations:							
	Average Strike	Average Dip	Direction	Strike from	Strike to	Dip from	Dip to
Set 1 (Primary 1)	25	53	NNE	20	30	42	64
Set 2 (Primary 2)	270	84	W	265	274	80	88
Set 3 (Secondary 1)	Unmappable						
Set 4 (Secondary 2)	Unmappable						
Set 5 (Foliation)	Unmappable						

Estimated Strength of Intact Rock Material:		
Designation:	Compressive Strength Range	Estimated in Field
Very High (15)	>250 Mpa (>36,260 psi)	
High (12)	100-250 Mpa (14,500-36,260 psi)	
Medium High (7)	50-100 Mpa (7,250-14,500 psi)	
Moderate (4)	25-50 Mpa (3,625-7,250 psi)	
Low (2)	5-25 Mpa (725-3,625 psi)	
Very Low (1)	1-5 Mpa (145-725 psi)	

Estimated Drill Core Quality (RQD)		
Designation:	RQD Percentage Range	Estimated in Field
Excellent Quality (20)	90-100%	
Good Quality (17)	75-90%	
Fair Quality (13)	50-75%	
Poor Quality (8)	25-50%	
Very Poor Quality (3)	<25%	

Spacing of Discontinuities						
		Set 1	Set 2	Set 3	Set 4	Set 5
Very Wide (20)	>2m (>6.5 ft)					
Wide (15)	0.6 - 2 m (2 - 6.5 ft)					
Moderate (10)	200-600 mm (8 - 24 in)					
Close (8)	60-200 mm (2.4 - 8 in)					
Very Close (5)	<60mm (<2.4 in)					

Discontinuity Persistence							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Low (6)	<1m (<3.3 ft)						Notes:
Low (4)	1 - 3 m (3.3 - 9.9 ft)						
Medium (2)	3 - 10 m (9.9 - 33 ft)						
High (1)	10 - 20 m (33 - 66 ft)						
Very High (0)	>20 m (>66 ft)						

Discontinuity Separation (Aperture)						
		Set 1	Set 2	Set 3	Set 4	Set 5
Very Tight Joints (6)	<0.1 mm (< 0.003 in)					
Tight Joints (5)	0.1 - 0.5 mm (0.003 - 0.02 in)					
Moderately Open Joints (4)	0.5 - 2.5 mm (0.02 - 0.1 in)					
Open Joints (1)	2.5 - 10 mm (0.1 - 0.4 in)					
Very Wide Aperture (0)	>10 mm (> 0.4 in)					

Discontinuity Roughness							
		Set 1	Set 2	Set 3	Set 4	Set 5	Notes:
Very Rough Surfaces (6)	VR						
Rough Surfaces (5)	R						
Slightly Rough Surfaces (3)	SR						
Smooth Surfaces (1)	SM						
Slickensided Surfaces (0)	SL						

Discontinuity Wall Face Weathering						
		Set 1	Set 2	Set 3	Set 4	Set 5
Unweathered (6)	UW					
Slightly Weathered (5)	SW					
Moderately Weathered (3)	MW					
Highly Weathered (1)	HW					
Completely Weathered (0)	CW					
Residual Soil (0)	RS					

RMR Classification:	**Unmappable**

Additional Notes:	Note: Scanline H is unmappable due to debris and active loading of haul trucks.
Groundwater conditions	
Discontinuity filling, staining	
Highwall trend, etc.	

APPENDIX A:

South Quarry of Morrison Quarry, Bench 6740, Scanline I, 15+25 - 18+00

Strike and Dip Orientations:							
	Average Strike	Average Dip	Direction	Strike from	Strike to	Dip from	Dip to
Set 1 (Primary 1)	250	69	WSW	1	359	53	76
Set 2 (Primary 2)	202	75	SSW	85	288	72	82
Set 3 (Secondary 1)	229	83	SW	220	235	71	90
Set 4 (Secondary 2)							
Set 5 (Foliation)	173	17	S	152	182	12	24

Estimated Strength of Intact Rock Material:		
Designation:	Compressive Strength Range	Estimated in Field
Very High (15)	>250 Mpa (>36,260 psi)	
High (12)	100-250 Mpa (14,500-36,260 psi)	X
Medium High (7)	50-100 Mpa (7,250-14,500 psi)	X
Moderate (4)	25-50 Mpa (3,625-7,250 psi)	
Low (2)	5-25 Mpa (725-3,625 psi)	
Very Low (1)	1-5 Mpa (145-725 psi)	

Estimated Drill Core Quality (RQD)		
Designation:	RQD Percentage Range	Estimated in Field
Excellent Quality (20)	90-100%	
Good Quality (17)	75-90%	
Fair Quality (13)	50-75%	X
Poor Quality (8)	25-50%	X
Very Poor Quality (3)	<25%	

Spacing of Discontinuities						
		Set 1	Set 2	Set 3	Set 4	Set 5
Very Wide (20)	>2m (>6.5 ft)	X	X	X		X
Wide (15)	0.6 - 2 m (2 - 6.5 ft)	X	X			X
Moderate (10)	200-600 mm (8 - 24 in)	X				X
Close (8)	60-200 mm (2.4 - 8 in)					
Very Close (5)	<60mm (<2.4 in)					

Discontinuity Persistence							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Low (6)	<1m (<3.3 ft)						Notes:
Low (4)	1 - 3 m (3.3 - 9.9 ft)			X			
Medium (2)	3 - 10 m (9.9 - 33 ft)	X		X			
High (1)	10 - 20 m (33 - 66 ft)	X	X			X	
Very High (0)	>20 m (>66 ft)					X	

Discontinuity Separation (Aperture)							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Tight Joints (6)	<0.1 mm (< 0.003 in)					X	
Tight Joints (5)	0.1 - 0.5 mm (0.003 - 0.02 in)	X		X		X	
Moderately Open Joints (4)	0.5 - 2.5 mm (0.02 - 0.1 in)	X	X	X			
Open Joints (1)	2.5 - 10 mm (0.1 - 0.4 in)		X				
Very Wide Aperture (0)	>10 mm (> 0.4 in)						

Discontinuity Roughness							
		Set 1	Set 2	Set 3	Set 4	Set 5	Notes:
Very Rough Surfaces (6)	VR						
Rough Surfaces (5)	R	X	X				
Slightly Rough Surfaces (3)	SR	X	X	X			
Smooth Surfaces (1)	SM					X	
Slickensided Surfaces (0)	SL						

Discontinuity Wall Face Weathering						
		Set 1	Set 2	Set 3	Set 4	Set 5
Unweathered (6)	UW	X	X	X		X
Slightly Weathered (5)	SW	X	X	X		X
Moderately Weathered (3)	MW					
Highly Weathered (1)	HW					
Completely Weathered (0)	CW					
Residual Soil (0)	RS					

RMR Classification:	32 - Poor	to	66 - Good

Additional Notes:	Minor oxide staining at top of highwall; generally fresh rock at bottom of highwall
Groundwater conditions	
Discontinuity filling, staining	
Highwall trend, etc.	

APPENDIX A:

South Quarry of Morrison Quarry, Bench 6740, Scanline J, 18+00 - 18+75

Strike and Dip Orientations:							
	Average Strike	Average Dip	Direction	Strike from	Strike to	Dip from	Dip to
Set 1 (Primary 1)	338	74	NNW	325	350	66	79
Set 2 (Primary 2)	95	81	E	0	265	67	90
Set 3 (Secondary 1)							
Set 4 (Secondary 2)							
Set 5 (Foliation)	158	26	SSE	102	242	20	41

Estimated Strength of Intact Rock Material:		
Designation:	Compressive Strength Range	Estimated in Field
Very High (15)	>250 Mpa (>36,260 psi)	
High (12)	100-250 Mpa (14,500-36,260 psi)	X
Medium High (7)	50-100 Mpa (7,250-14,500 psi)	X
Moderate (4)	25-50 Mpa (3,625-7,250 psi)	
Low (2)	5-25 Mpa (725-3,625 psi)	
Very Low (1)	1-5 Mpa (145-725 psi)	

Estimated Drill Core Quality (RQD)		
Designation:	RQD Percentage Range	Estimated in Field
Excellent Quality (20)	90-100%	
Good Quality (17)	75-90%	
Fair Quality (13)	50-75%	
Poor Quality (8)	25-50%	
Very Poor Quality (3)	<25%	X

Spacing of Discontinuities						
		Set 1	Set 2	Set 3	Set 4	Set 5
Very Wide (20)	>2m (>6.5 ft)					
Wide (15)	0.6 - 2 m (2 - 6.5 ft)		X			X
Moderate (10)	200-600 mm (8 - 24 in)	X	X			X
Close (8)	60-200 mm (2.4 - 8 in)	X				
Very Close (5)	<60mm (<2.4 in)					

Discontinuity Persistence							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Low (6)	<1m (<3.3 ft)		X				Notes:
Low (4)	1 - 3 m (3.3 - 9.9 ft)	X					
Medium (2)	3 - 10 m (9.9 - 33 ft)					X	
High (1)	10 - 20 m (33 - 66 ft)						
Very High (0)	>20 m (>66 ft)						

Discontinuity Separation (Aperture)							
		Set 1	Set 2	Set 3	Set 4	Set 5	
Very Tight Joints (6)	<0.1 mm (< 0.003 in)						
Tight Joints (5)	0.1 - 0.5 mm (0.003 - 0.02 in)	X				X	
Moderately Open Joints (4)	0.5 - 2.5 mm (0.02 - 0.1 in)	X	X			X	
Open Joints (1)	2.5 - 10 mm (0.1 - 0.4 in)		X			X	
Very Wide Aperture (0)	>10 mm (> 0.4 in)						

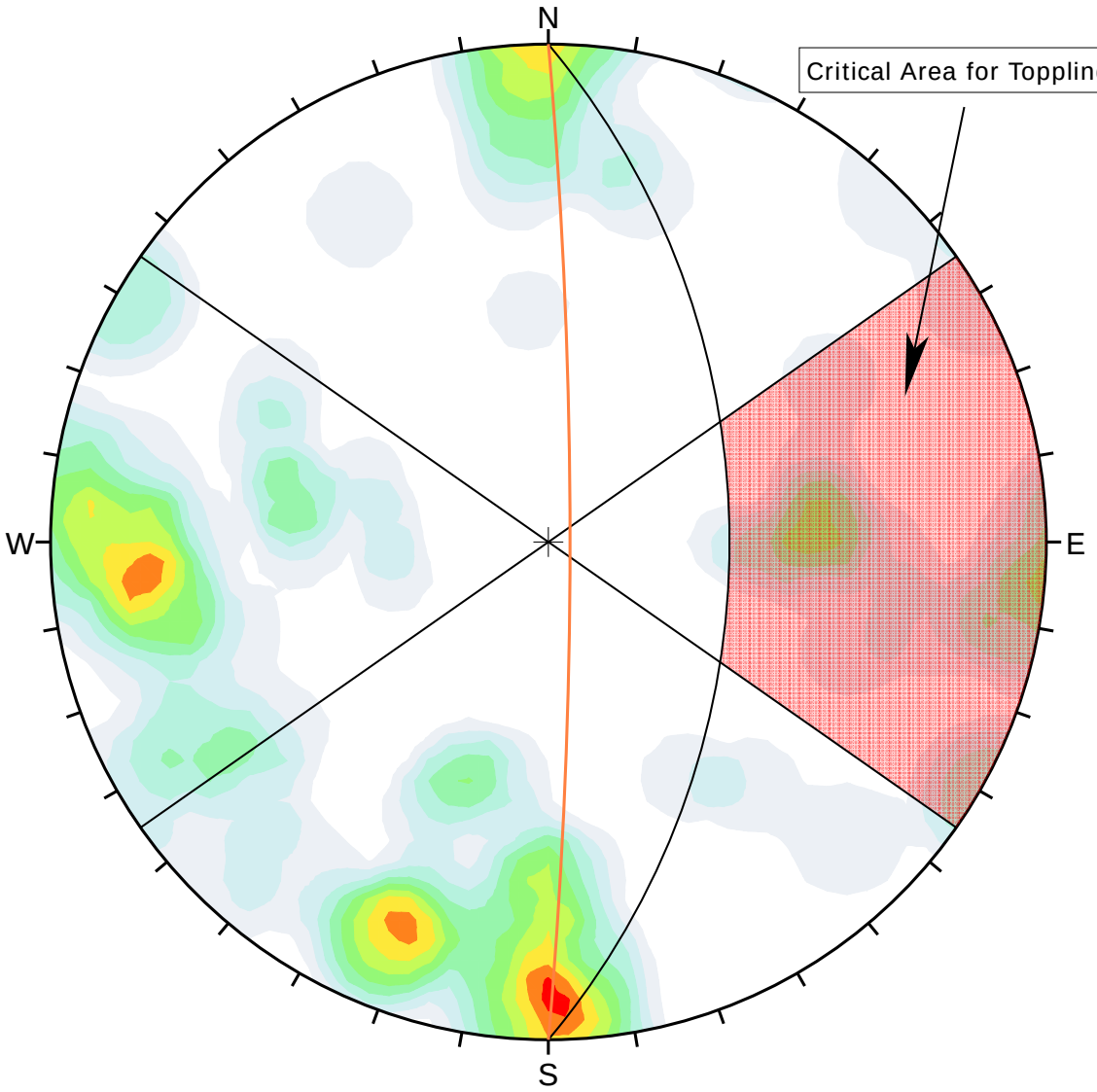
Discontinuity Roughness							
		Set 1	Set 2	Set 3	Set 4	Set 5	Notes:
Very Rough Surfaces (6)	VR						
Rough Surfaces (5)	R	X	X			X	
Slightly Rough Surfaces (3)	SR	X				X	
Smooth Surfaces (1)	SM	X					
Slickensided Surfaces (0)	SL						

Discontinuity Wall Face Weathering						
		Set 1	Set 2	Set 3	Set 4	Set 5
Unweathered (6)	UW					
Slightly Weathered (5)	SW	X	X			X
Moderately Weathered (3)	MW		X			
Highly Weathered (1)	HW					
Completely Weathered (0)	CW					
Residual Soil (0)	RS					

RMR Classification:	25 - Poor	to	51 - Fair

Additional Notes:	Pegmatite at corner; localized oxide staining; pegmatite separates good rock from weaker rock
Groundwater conditions	
Discontinuity filling, staining	
Highwall trend, etc.	

Appendix B Stereonets



Color	Density Concentrations
	0.00 - 0.80
	0.80 - 1.60
	1.60 - 2.40
	2.40 - 3.20
	3.20 - 4.00
	4.00 - 4.80
	4.80 - 5.60
	5.60 - 6.40
	6.40 - 7.20
	7.20 - 8.00

Contour Data	Pole Vectors
Maximum Density	7.58%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Flexural Toppling
Slope Dip	85
Slope Dip Direction	90
Friction Angle	35°
Lateral Limits	35°

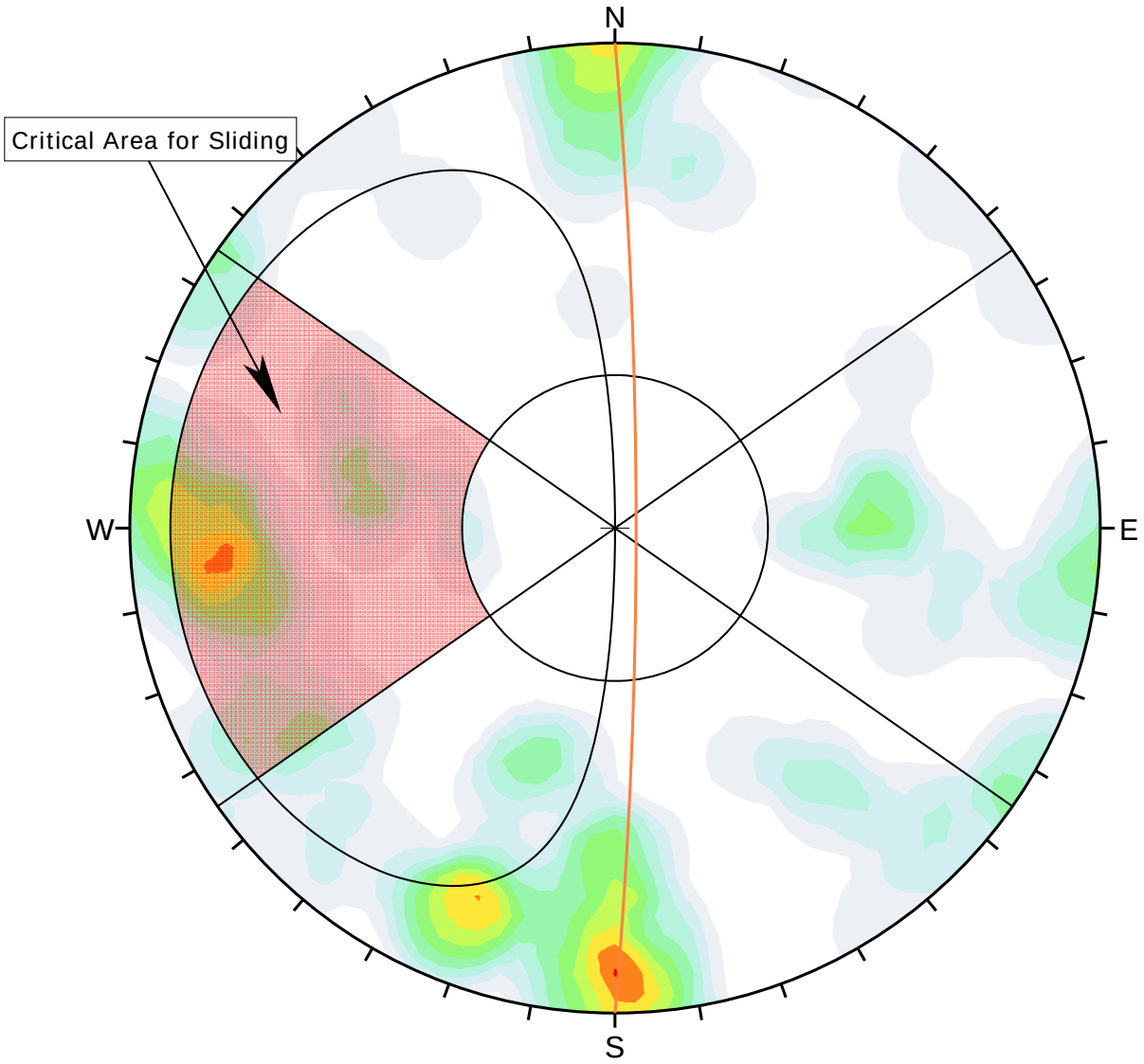
	Critical	Total	%
Flexural Toppling (All)	10	69	14.49%

Plot Mode	Pole Vectors
Vector Count	69 (69 Entries)
Hemisphere	Lower
Projection	Equal Angle

GEI Consultants

DIPS 7.014

Project	2019 MORRISON QUARRY ANNUAL REPORT		
Analysis Description	FLEXURAL TOPPLING		
Drawn By	N. JORGENSEN	*Company*	GEI CONSULTANTS, INC.
Date	DECEMBER 23, 2019	*File Name*	Bench 6740 - Flexural Topping.dips7



Color	Density Concentrations
	0.00 - 0.80
	0.80 - 1.60
	1.60 - 2.40
	2.40 - 3.20
	3.20 - 4.00
	4.00 - 4.80
	4.80 - 5.60
	5.60 - 6.40
	6.40 - 7.20
	7.20 - 8.00

Contour Data	Pole Vectors
Maximum Density	7.26%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Planar Sliding
Slope Dip	85
Slope Dip Direction	90
Friction Angle	35°
Lateral Limits	35°

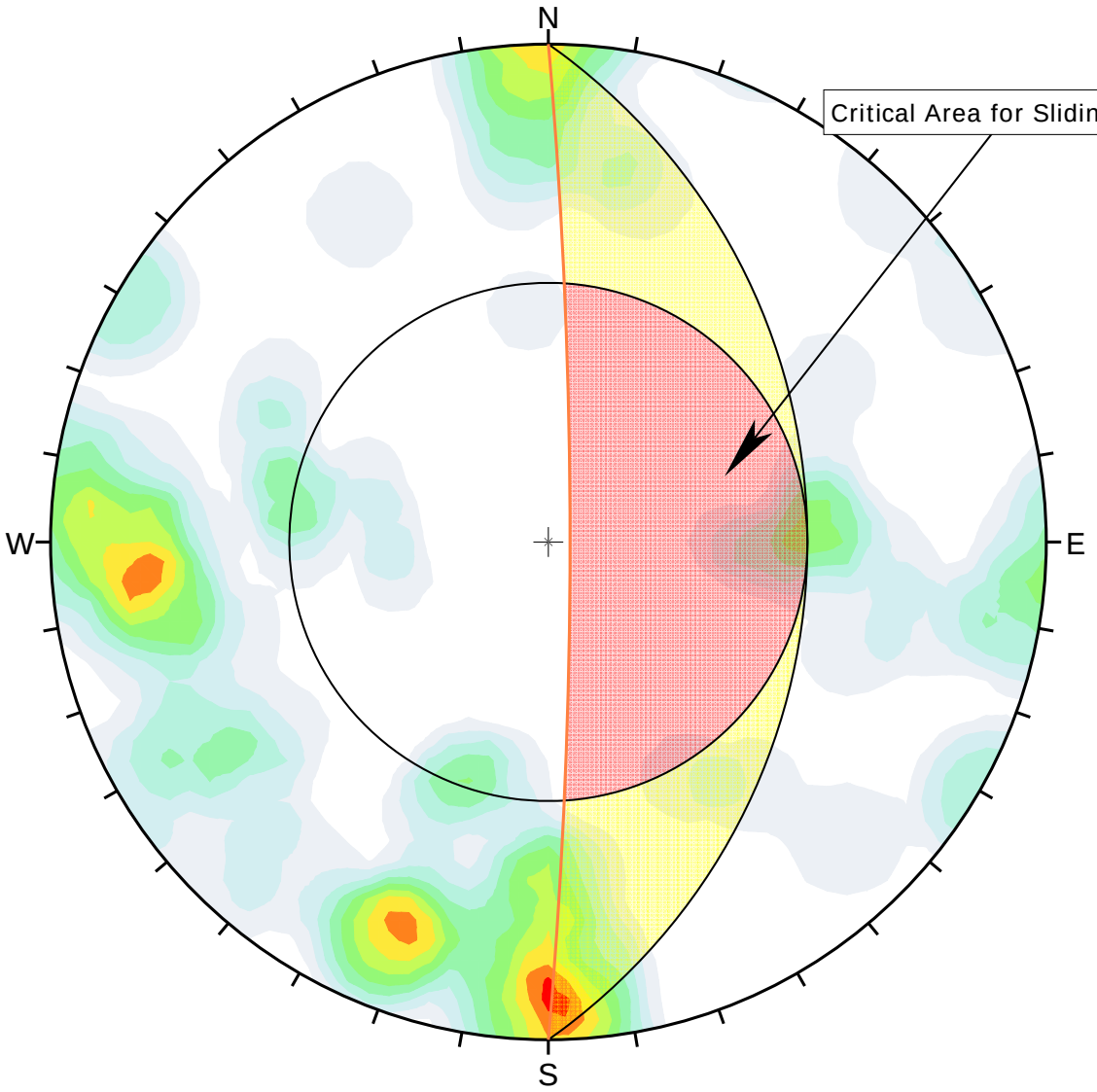
	Critical	Total	%
Planar Sliding (All)	19	72	26.39%

Plot Mode	Pole Vectors
Vector Count	72 (72 Entries)
Hemisphere	Lower
Projection	Equal Angle

GEI Consultants

DIPS 7.014

Project	2019 MORRISON QUARRY ANNUAL REPORT		
Analysis Description	PLANAR SLIDING - GLOBAL		
Drawn By	N. JORGENSEN	*Company*	GEI CONSULTANTS, INC.
Date	DECEMBER 23, 2019	*File Name*	Bench 6740 - Planar Sliding.dips7



Color	Density Concentrations
	0.00 - 0.80
	0.80 - 1.60
	1.60 - 2.40
	2.40 - 3.20
	3.20 - 4.00
	4.00 - 4.80
	4.80 - 5.60
	5.60 - 6.40
	6.40 - 7.20
	7.20 - 8.00

Contour Data	Pole Vectors
Maximum Density	7.58%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	85
Slope Dip Direction	90
Friction Angle	35°

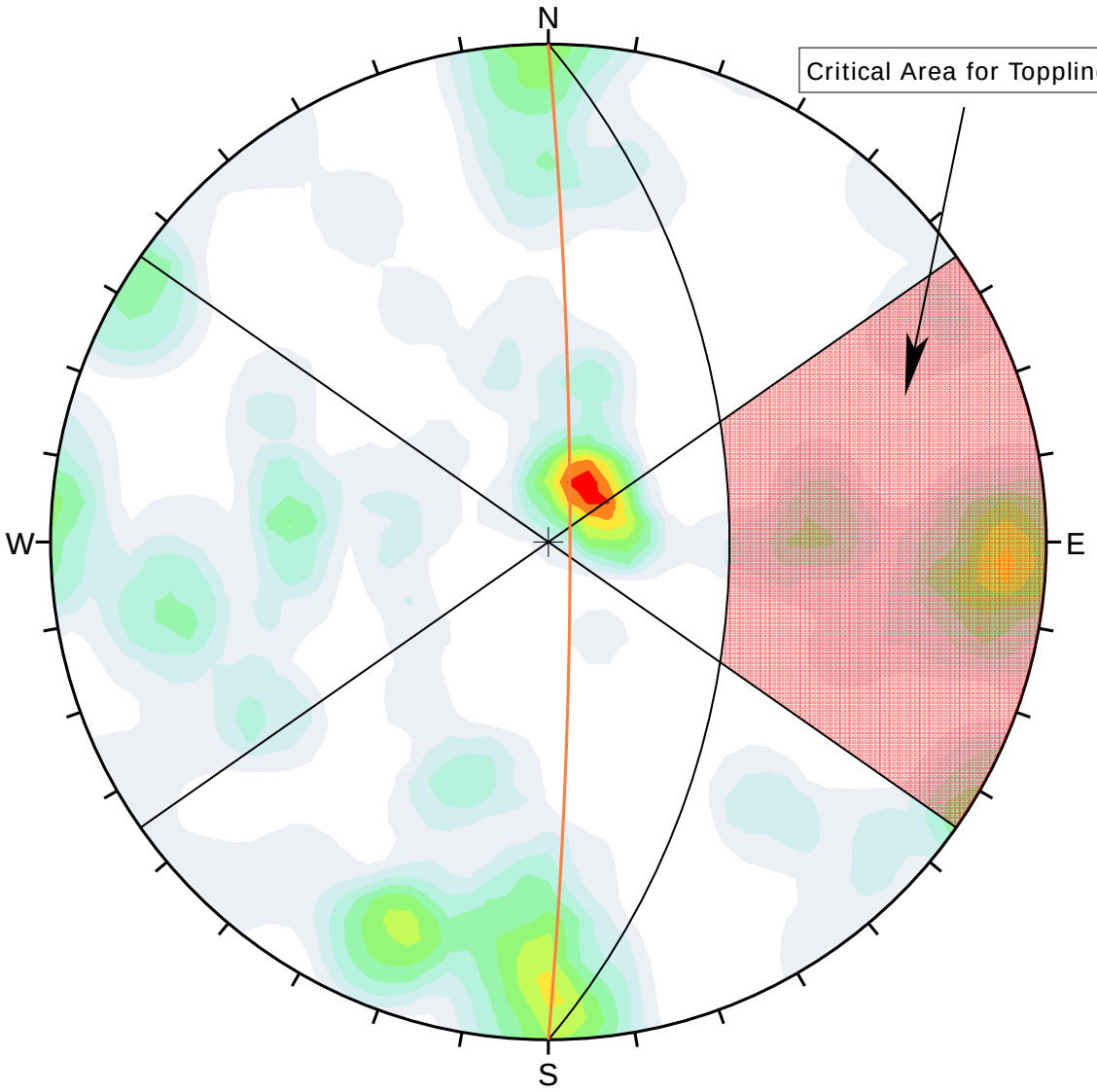
	Critical	Total	%
Wedge Sliding	1042	2344	44.45%

Plot Mode	Pole Vectors
Vector Count	69 (69 Entries)
Hemisphere	Lower
Projection	Equal Angle

GEI Consultants

DIPS 7.014

Project	2019 MORRISON QUARRY ANNUAL REPORT		
Analysis Description	WEDGE SLIDING		
Drawn By	N. JORGENSEN	*Company*	GEI CONSULTANTS, INC.
Date	DECEMBER 23, 2019	*File Name*	Bench 6740 - Wedge Sliding.dips7



Color	Density Concentrations
	0.00 - 0.70
	0.70 - 1.40
	1.40 - 2.10
	2.10 - 2.80
	2.80 - 3.50
	3.50 - 4.20
	4.20 - 4.90
	4.90 - 5.60
	5.60 - 6.30
	6.30 - 7.00

Contour Data	Pole Vectors
Maximum Density	6.83%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Flexural Toppling
Slope Dip	85
Slope Dip Direction	90
Friction Angle	35°
Lateral Limits	35°

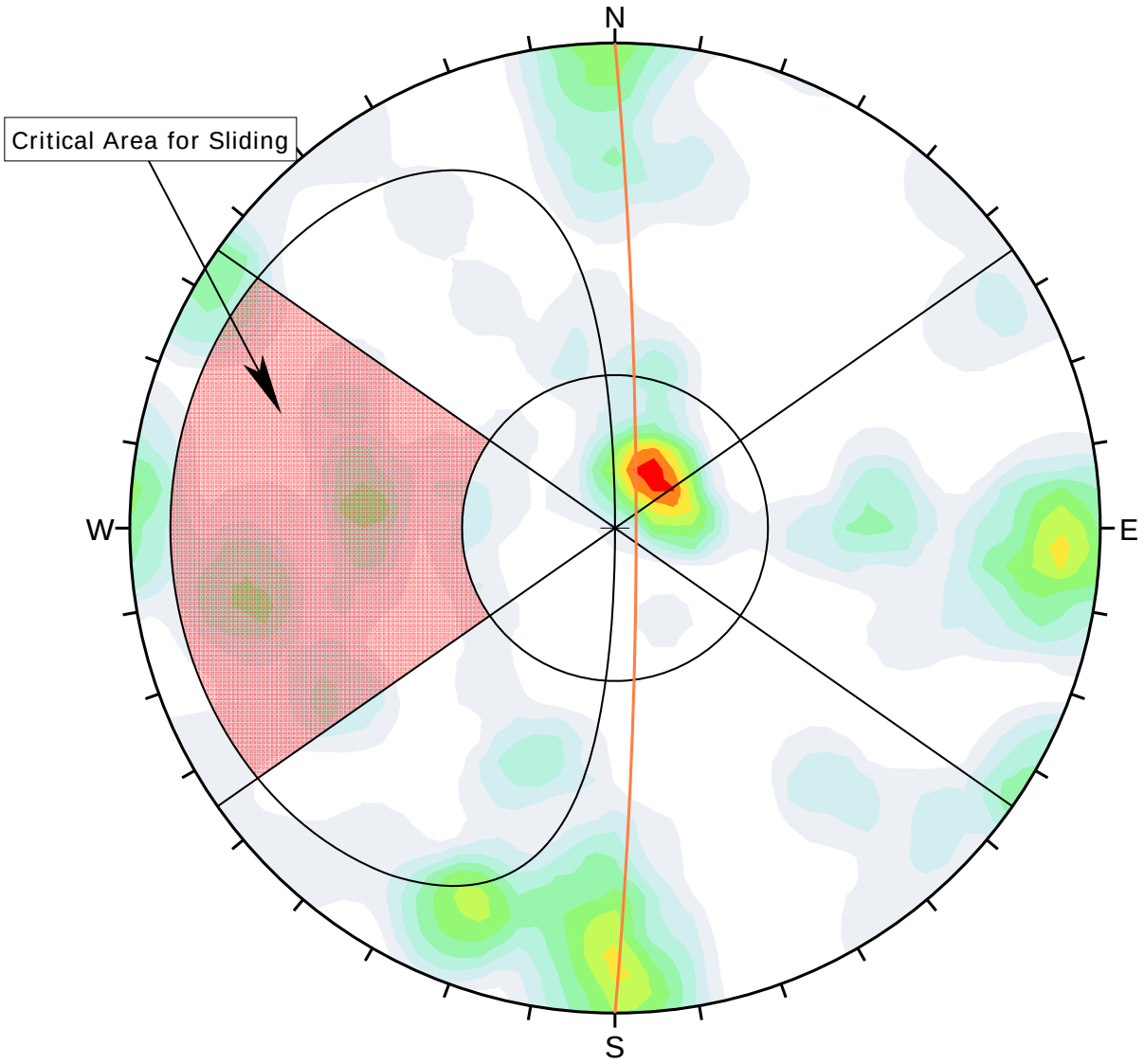
	Critical	Total	%
Flexural Toppling (All)	14	104	13.46%

Plot Mode	Pole Vectors
Vector Count	104 (104 Entries)
Hemisphere	Lower
Projection	Equal Angle

GEI Consultants

DIPS 7.014

Project	2019 MORRISON QUARRY ANNUAL REPORT		
Analysis Description	FLEXURAL TOPPLING - GLOBAL		
Drawn By	N. JORGENSEN	*Company*	GEI CONSULTANTS, INC.
Date	DECEMBER 23, 2019	*File Name*	Global - Flexural Toppling.dips7



Color	Density Concentrations
	0.00 - 0.70
	0.70 - 1.40
	1.40 - 2.10
	2.10 - 2.80
	2.80 - 3.50
	3.50 - 4.20
	4.20 - 4.90
	4.90 - 5.60
	5.60 - 6.30
	6.30 - 7.00

Contour Data	Pole Vectors
Maximum Density	6.83%
Contour Distribution	Fisher
Counting Circle Size	1.0%

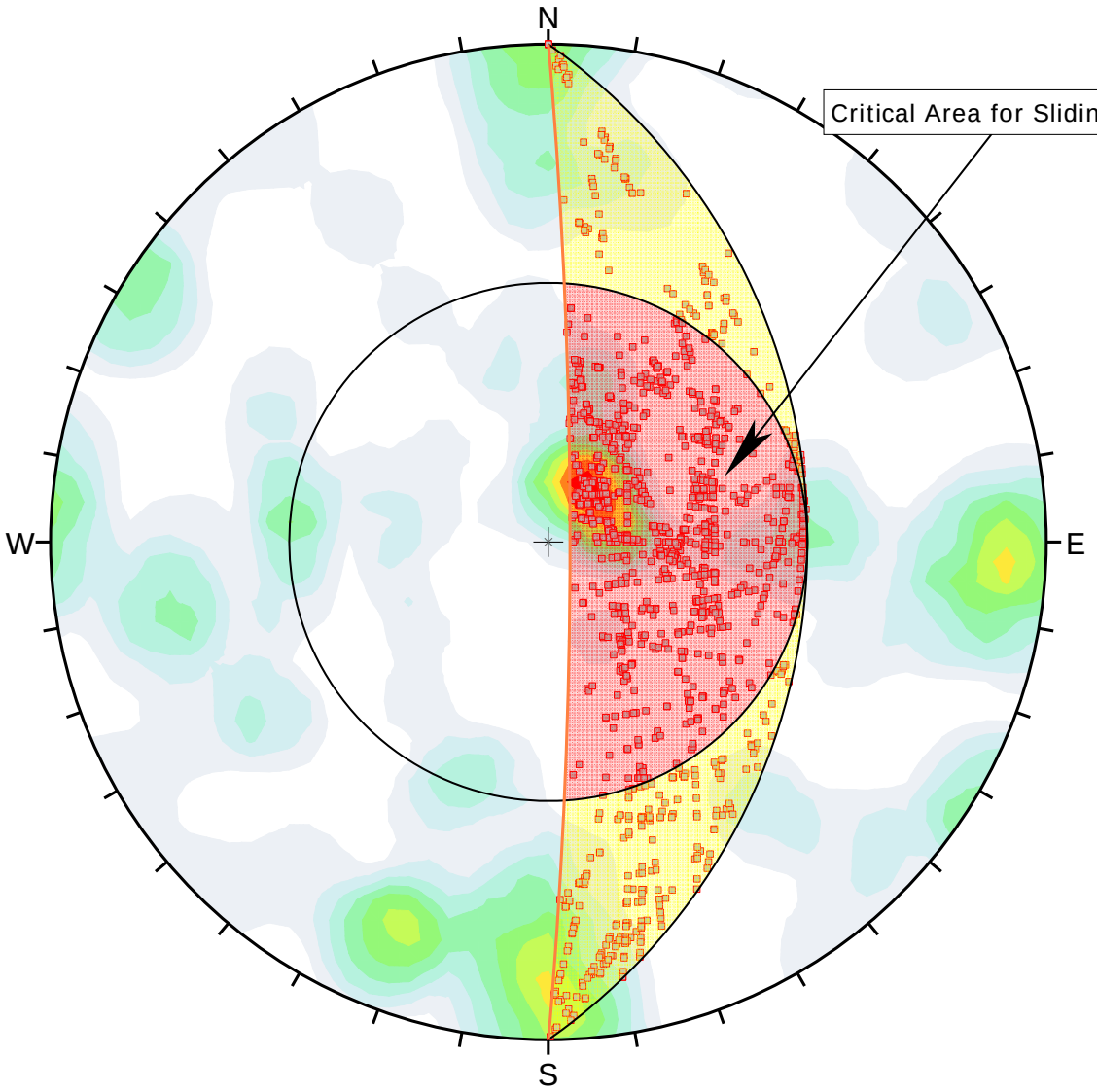
Kinematic Analysis	Planar Sliding		
Slope Dip	85		
Slope Dip Direction	90		
Friction Angle	35°		
Lateral Limits	35°		
	Critical	**Total**	**%**
Planar Sliding (All)	19	104	18.27%

Plot Mode	Pole Vectors
Vector Count	104 (104 Entries)
Hemisphere	Lower
Projection	Equal Angle

GEI Consultants

DIPS 7.014

Project	2019 MORRISON QUARRY ANNUAL REPORT		
Analysis Description	PLANAR SLIDING - GLOBAL		
Drawn By	N. JORGENSEN	*Company*	GEI CONSULTANTS, INC.
Date	DECEMBER 23, 2019	*File Name*	Global - Planar Sliding.dips7



Symbol	Feature
▫	Critical Intersection

Color	Density Concentrations
	0.00 - 0.70
	0.70 - 1.40
	1.40 - 2.10
	2.10 - 2.80
	2.80 - 3.50
	3.50 - 4.20
	4.20 - 4.90
	4.90 - 5.60
	5.60 - 6.30
	6.30 - 7.00

Contour Data	Pole Vectors
Maximum Density	6.83%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	85
Slope Dip Direction	90
Friction Angle	35°

	Critical	Total	%
Wedge Sliding	1389	5353	25.95%

Plot Mode	Pole Vectors
Vector Count	104 (104 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	5353
Hemisphere	Lower
Projection	Equal Angle

GEI Consultants

DIPS 7.014

Project	2019 MORRISON QUARRY ANNUAL REPORT		
Analysis Description	WEDGE SLIDING - GLOBAL		
Drawn By	N. JORGENSEN	*Company*	GEI CONSULTANTS, INC.
Date	DECEMBER 23, 2019	*File Name*	Global - Wedge Sliding.dips7