Revision 2021-1
Ground Control Management Plan
Underground Operations
Minto Mine, YT

Prepared by:
Minto Explorations Ltd.
Minto Mine
June 2021

Minto Mine Ground Control Management Plan—Underground Operations

First Issue: July 2013

REVISION INFORMATION

Rev. Number	Issue Date	Description & Location of Revisions Made
0	July 17, 2013	First issue
2014-1	June, 2014	Update of rock mass characterization. Revisions to ground support standards.
2015-1	December, 2015	Update of rock mass characterization with mapping data. Update of mine plan to exclude M-Zone and include the updated Area 118 underground.
2016-1	December, 2016	Update of rock mass characterization with mapping and drilling data. Update of mine plan to include the Area 2 underground.
2017-1	December, 2017	Update of rock mass characterization with mapping and drilling data. Update of mine plan to include Minto East.
2019-1	December, 2019	Update of mining areas. Update to detail of stope design.
2020-1	June, 2020	Update ground support standards and elements Include kinematic analysis Copper Keel support
2021-1	June, 2021	Update of mining Areas. Update to Copper Keel rock mass characterization.

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Date: 3rd June 2021

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General Statement and Corporate Message

Minto Explorations Ltd. Minto Mine maintains the health and safety of the people involved in activities at the mine as the primary value entrenched into everything we do. We strive for "Safe Production" by ensuring people clearly understand that no one is expected to work in substandard conditions, with substandard tools or put them self or others at risk in any way performing their duties at Minto Mine. We maintain a Target ZERO philosophy that believes all incidents are preventable and that every effort must be made to eliminate significant accidents and reduce minor incidents toward ZERO.

Introduction

The purpose of this Ground Control Management Plan (GCMP) is to provide a system for the management of ground control at Minto's underground operations. The Ground Control Management Plan shall:

- outline systems for evaluating, designing, maintaining, and monitoring excavation stability to prevent personal injury, damage to equipment or loss to process.
- present a structure that defines core responsibilities and accountabilities.
- develop and maintain a process for hazard identification and risk management regarding ground control and geotechnical mine design; and,
- introduce methods to effectively monitor and measure compliance to legislative regulations and corporate policy through audit and review processes.

The intent of the GCMP is therefore to outline the strategies aimed at eliminating or minimizing the risk of falls of ground or collapse in the underground operations which may result in fatalities, injuries, equipment damage or loss of production.

The GCMP is a live document that will change continuously with new standards, technology, working procedures and annual reviews, and applies to all personnel at Minto Mine.

Document Layout

The GCMP has three parts:

Part One: Design

This section discusses the processes undertaken to determine the excavation design parameters, support requirements, and mining methods applied in the various underground areas. This includes a summary of the site geology, rock mass characterization, minimum ground support standards and practices to manage the predicted ground conditions.

Part Two: Implementation

This section discusses the procedures and systems for implementing the designed ground control program. This includes Safe Work Practices for ground support installation, a hazard recognition program, ground control communication systems, workforce training and emergency response.

Part Three: Monitoring and Verification

This section outlines practices and procedures for verifying the ground control design. This includes inspections and data collection, quality assurance/quality control, audits, updates and reviews of the Ground Control Management Plan.

Accountability and Responsibilities

Responsibilities for personnel involved with the underground operations include the following:

General Manager

The General Manager has the overall responsibility for the GCMP. The General Manager shall ensure that:

- suitably trained and qualified persons are formally appointed to the following positions:
    - Mine Director.
    - Chief Engineer.
    - Safety/Training Coordinator.
    - Geotechnical Engineer.

Mine Director

The Mine Director shall ensure that:

- the GCMP is implemented and all regulatory requirements are met.
- adequate resources are allocated, and competent technical and operational personnel are appointed.

Chief Engineer

The Chief Engineer shall ensure that:

- the GCMP is reviewed/updated at the required frequency.
- adequate training is given to the geotechnical engineer, geologists, and mine engineers.
- Safe Work Practices (SWP's) and Safe Job Procedures (SJP's) are developed, reviewed, and modified when needed, in conjunction with the Health and Safety Department.

Geotechnical Engineer

The Geotechnical Engineer shall ensure that:

- geotechnical conditions are adequately considered in relation to the mine design and planning.
- monitoring, auditing, and testing systems are developed and maintained.
- on-going mapping, data collection and inspections are carried out to identify variations in ground conditions; and,

- ground control directives are issued for specific conditions/excavations not covered in this document.

Underground Superintendent, Mine Captains and Supervisors

The Underground Superintendent and Supervisors shall ensure that:

- the work sites and the travel ways are adequately supported through adherence to the ground control requirements set out in the layouts.
- suitable equipment is supplied and maintained to the specifications required for quality ground control.
- Safe Work Practices (SWP's) and Safe Job Procedures (SJP's) are implemented and monitored to ensure compliance.
- any unusual ground conditions are noted and brought to the attention of the engineering group.
- all personnel under their control receive appropriate training.
- the designed support/reinforcement is installed to the specified standards; and,
- reports on ground falls, and variations to ground support standards are addressed and distributed as required. Any anomalies concerning ground control issues are logged in the Ground Control Logbook.

All Operational Personnel

All operational personnel shall ensure that:

- no work is undertaken without an approved plan.
- only work in line with current competencies is undertaken.
- Safe Work Practices (SWP's) and Safe Job Procedures (SJP's) are followed.
- ground conditions are inspected in line with workplace inspection standards at every work site.
- ground conditions are monitored during the shift for the presence of loose or unstable ground.
- if any rock noise is heard or the ground being worked appears unsafe, withdraw, and barricade the area, then immediately notify the Supervisor; and,
- relevant information in relation to ground conditions/support is reported back to the Supervisor and Geotechnical Engineer.

Mandatory Requirements

- NO PERSON IS TO ENTER UNSUPPORTED GROUND.
- Supported (secured) ground is deemed to be ground where a complete ground support system has been applied as per required standards.
- All man-entry excavations must conform to or exceed the minimum ground control standards specified in this document.
- All ground control work must follow established Safe Work Practices (SWP's) and Safe Job Procedures (SJP's).
- All personnel must inspect ground conditions and check the adequacy of ground control when entering an underground heading/access/work area.
- All personnel must immediately report uncontrolled falls of ground and ground control hazards to their supervisor who will be responsible for follow up and documentation.
- All reports of conditions requiring actions outside of standard work will be recorded in the Ground Control Logbook and followed-up with a documented inspection to ensure the efficacy of the remedial action.

Part One: Design

The mine design is determined by the geological, geotechnical, and hydrogeological data collected to characterize the Minto ore bodies. Data collected for use in mine design and the design processes are detailed in this section.

1 Description of the Mine

Minto Mine is situated in the Whitehorse Mining District in the central Yukon Territory. The property is located approximately 240 km northwest of Whitehorse, the Yukon capital. Underground mining is currently taking place in the Copper Keel zone and concluding in Minto East. Minto East 2 is scheduled to begin mining in 2021 to 2022. All areas are accessed by the Minto South portal. Future mining will include Minto North 2 (commencing 2021 – 2022). This will be accessed by a portal driven into the pit wall of Minto North Pit. Ground conditions are anticipated to be like our current underground workings (based on exploration drilling core data to date) and similar support standards to that used currently will be employed. This document will be updated with Minto North 2 Geotechnical data as soon as this becomes available.

Figure 1: Plan view of Minto Mine (June, 2021)

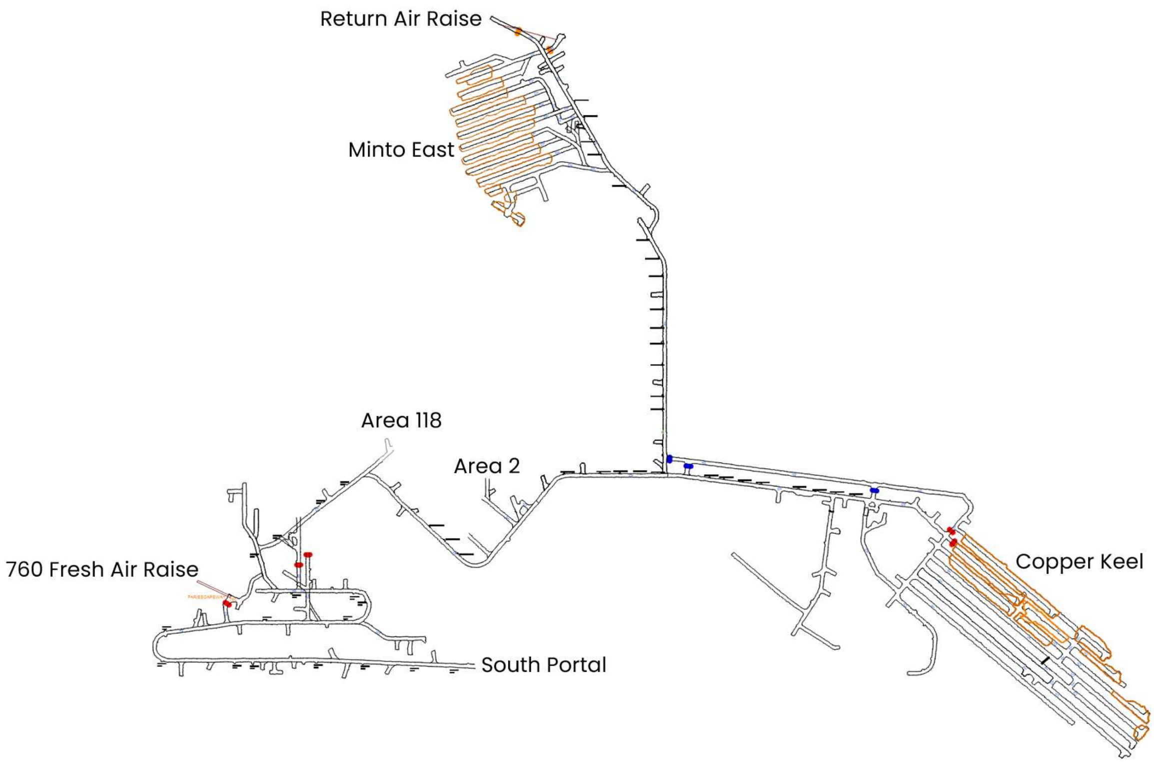


Figure 2: Plan of Underground Workings (June, 2021)

2 Rock Mass Characterization

2.1 Geological Overview

Copper sulphide mineralization at Minto is hosted wholly within the Minto pluton, predominantly of granodiorite composition. Hood et al. (2008) distinguish three varieties of the intrusive rocks in the pluton:

- Megacrystic K-feldspar Granodiorite - gradually ranges in mineralogy to quartz diorite and rarely to quartz monzonite or granite, typically maintaining a massive igneous texture. An exception occurs locally where weakly to strongly foliated granodiorite is seen in distinct sub-parallel zones several metres to tens of metres thick.

- Quartzo-feldspathic Gneiss – composed of centimeter-thick compositional layering and folded by centimetre to decimetre-scale disharmonic, gentle to isoclinal folds (Hood et al., 2008).

- Biotite-rich Gneiss.

Minto geologists consider all units to be similar in origin and are variably deformed equivalents of the same intrusion; however, copper sulphide mineralization is found in the rocks that have a structurally imposed fabric, ranging from a weak foliation to strongly developed gneissic banding. For this reason, all logging/mapping separates the foliated to gneissic textured granodiorite as a distinct unit.

Other rock types, albeit volumetrically insignificant, include dykes of simple quartz-feldspar pegmatite, aplite, and an aphanitic textured intermediate composition rock. Bodies of all these units are relatively thin and rarely exceed one metre intersections.

2.1.1 Geologic Structure

Both ductile and brittle phases of deformation are found around the Minto deposits. As noted above, copper-sulphide mineralization is strongly associated with foliated granodiorite. This foliation is defined by the alignment of biotite in areas of weak to moderate strain and by the segregation of quartz and feldspar into bands in areas of higher strain, giving the rock a gneissic texture in very strongly deformed areas. The deformation zone forms sub-horizontal horizons within the more massive plutonic rocks of the region that can be traced laterally for more than 1,000 m. The horizons are often stacked in parallel to sub-parallel sequences.

Internally, the foliation exhibits highly variable orientations within individual horizons with the presence of small-scale folds. The foliation is often observed to be at a high angle to contacts with more massive textured rock units.

Late brittle fracturing and faulting is noted throughout the property. The boundary between Area 2 and Area 118 is an intermediate NE dipping fault with significant displacement of mineralization.

The easiest zone to identify (based on mineralization and texture) is the “N” zone which has up to 66 m of vertical throw across the boundary fault. Other zones show changes in thickness and orientation, suggesting the presence of pure strain and block rotation.

2.2 Geotechnical Model

2.2.1 Rock Types

For most of the underground excavations completed at Minto, granodiorite is the major intersected unit. As discussed in Section 2.1, mineralization typically occurs in foliated to gneissic variations of the host granodiorite. Experience to date indicates the waste rock typically has slightly higher intact strength but more continuous fractures than ore, although both are variable and often influenced by fault zones.

2.2.2 Discontinuities

Extensive structural mapping was carried out in Area 118, M-Zone, Area 2 and Minto East as summarized in Table 1.and Table 2.

Structural data collected in the underground workings to date have been combined into ore and waste stereonets, presented in Figures 3 and 4.

In general, the sets result in conditions varying in waste rock from moderately blocky to very blocky and typically wedge-prone. Discontinuities in waste rock are typically very continuous, extending larger than the excavation size. In ore, the sets are less persistent and more widely spaced, resulting in only occasional blocky conditions. Few wedges have been observed in ore exposures to date.

Several faults have been observed in the development at various orientations. Most are relatively discrete structures with limited width and minor alteration of the wall rock; however, several were intersected in Area 118 and Area 2 that have several meters of weak, altered rock or are water-bearing indicating they are open and continuous. The 320 Fault, which was a major fault seen in the Area 2 pit, and intersected in the A2 ramp, has a more extensive alteration zone up to 25 m, containing altered and filled structures and occasional fault gouge. The 320 Fault is more problematic near surface and did not present major challenges for the underground ramp development. The Minto East Fault has been intersected in the Minto East ramp and is modelled to cross-cut the sill development within the Minto East deposit.

Fault orientations summarized in Table 2, typically align with joint set J8 and follow a regional trend like the Teslin and Tintina Faults.

The geological model is updated annually or more frequently as required such as the development of a new area.

Table 1: Major Joint Sets

Major Joint Set	Average Dip	Average Dip Direction	Primary Lithology	Typical Joint Length (m)	Area Observed	Comments
J2	88	077	Ore	2	• Area 118	Major set in ore. Not apparent in waste.
J2b	83	256	Ore	2	• Area 118 • Area 2	Major set in ore. Not apparent in waste.
J3	71(waste) 72(ore)	133(waste) 139(ore)	Waste	6(waste) 2(ore)	• M-Zone • Area 118 • Minto East	Major set in all areas. Not apparent in Area 2.
J3b	39	135	Waste	6	• M-Zone • Area 118 • Minto East	Major set in all areas. Not apparent in Area 2.
J4	72(waste) 74(ore)	163(waste) 166(ore)	Waste	6(waste) 2(ore)	• M-Zone • Area 118	Major set in most areas.
J6	81	359	Ore	2	• M-Zone • Area 118	Minor set in ore. Not apparent in Area 2.
J8	82	043	Waste	6	• Area 118 • Area 2 • Minto East	Major set in Area 2 Pit. Major set in Area 118 and Minto East. Major set in Area 2 ore – not apparent in Area 2 waste.
J8b	80	225	Waste	6	• Area 118 • Area 2 • Minto East	Major set in Area 2 and Minto East. Minor set in Area 118.
J9	13	103	Waste	4	• Area 118 • Area 2	Minor set in Area 118, Moderate set in Area 2. Not apparent in ore.
J11	82	273	Waste	2	• Area 2	Moderate set in Area 2 waste.

Table 2: Major Structures

Structure Description	Average Dip	Average Dip Direction	Comments
Fault	66 (65-76)	035 (015-040)	Major fault intersected throughout Area 118 waste and ore development. Zone of up to several meters of altered, weak rock. Often water bearing. Similar structure intersected in the Minto East ramp development.
Fault	64-74	040-050	Major fault zone in Area 2 (“320 Fault”) and regional fault orientation. Up to 5m zone of gouge, altered fractured rock.
Fault	50-55	038-036	Major fault zone in Minto East. Up to 3m zone of gouge, altered fractured rock. Very limited exposure in development to date but modelled to cross all development sills.
Fault	60	160	Gouge filled fault in M-Zone.
Fault	59	292	Minor fault in Area 118 waste rock.

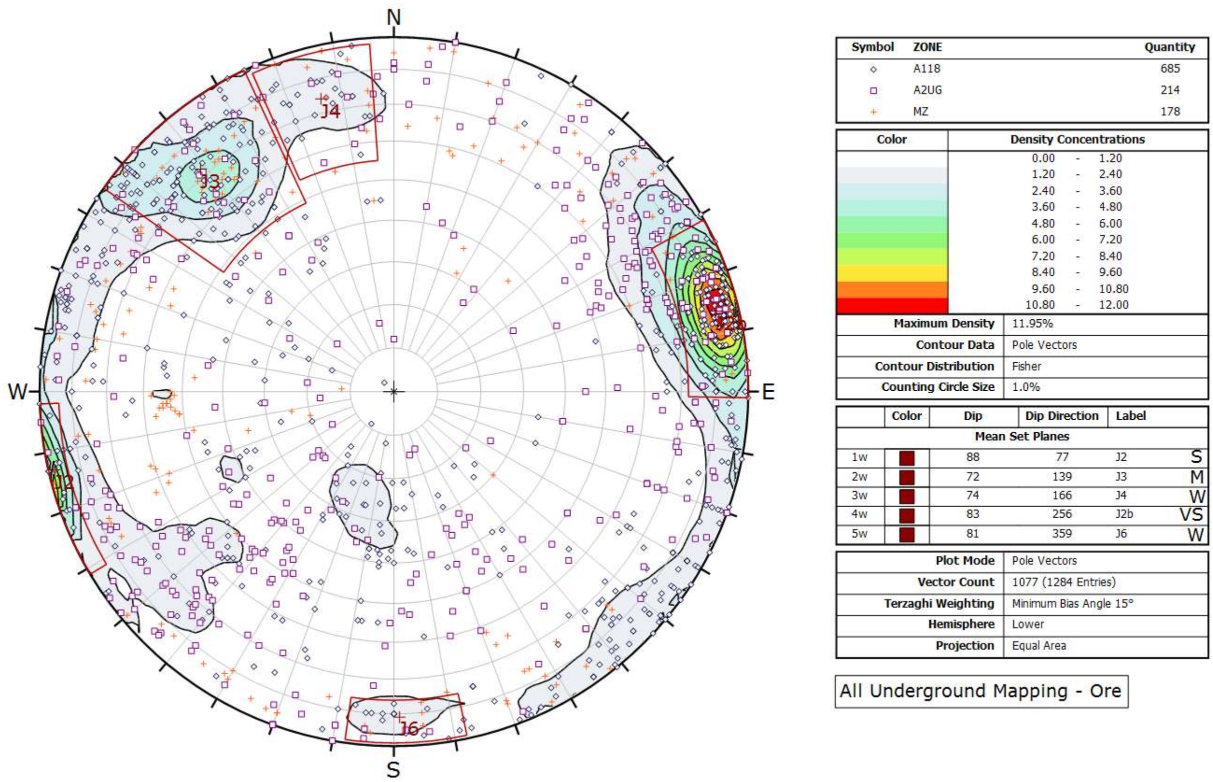


Figure 3: Mapping - Ore

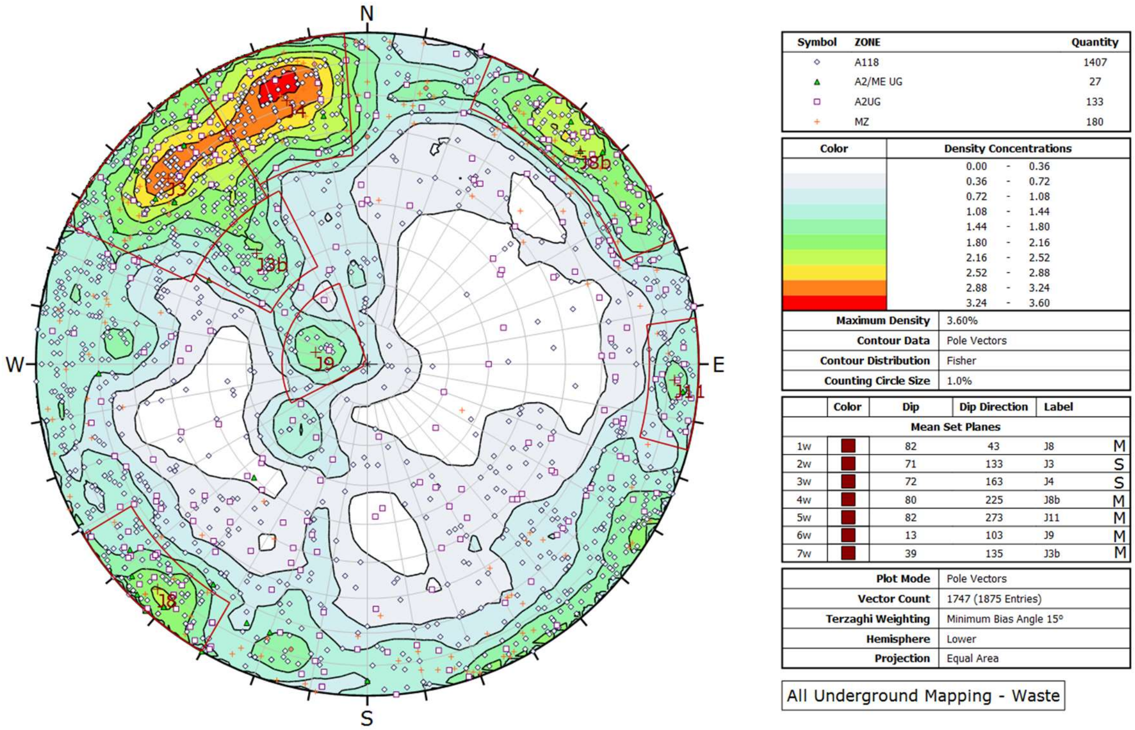


Figure 4: Mapping - Waste

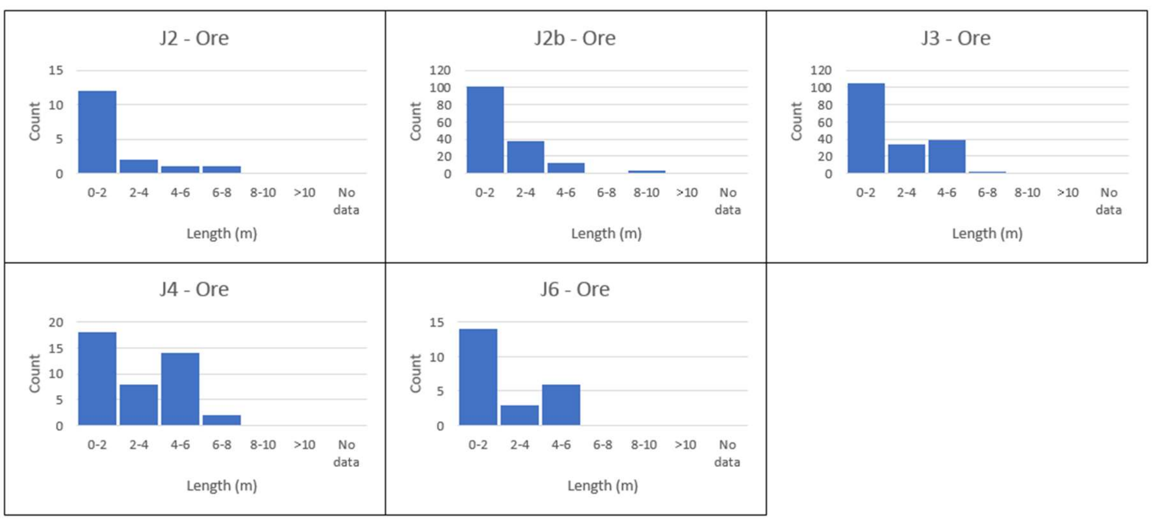


Figure 5: Mapping – Joint lengths in Ore

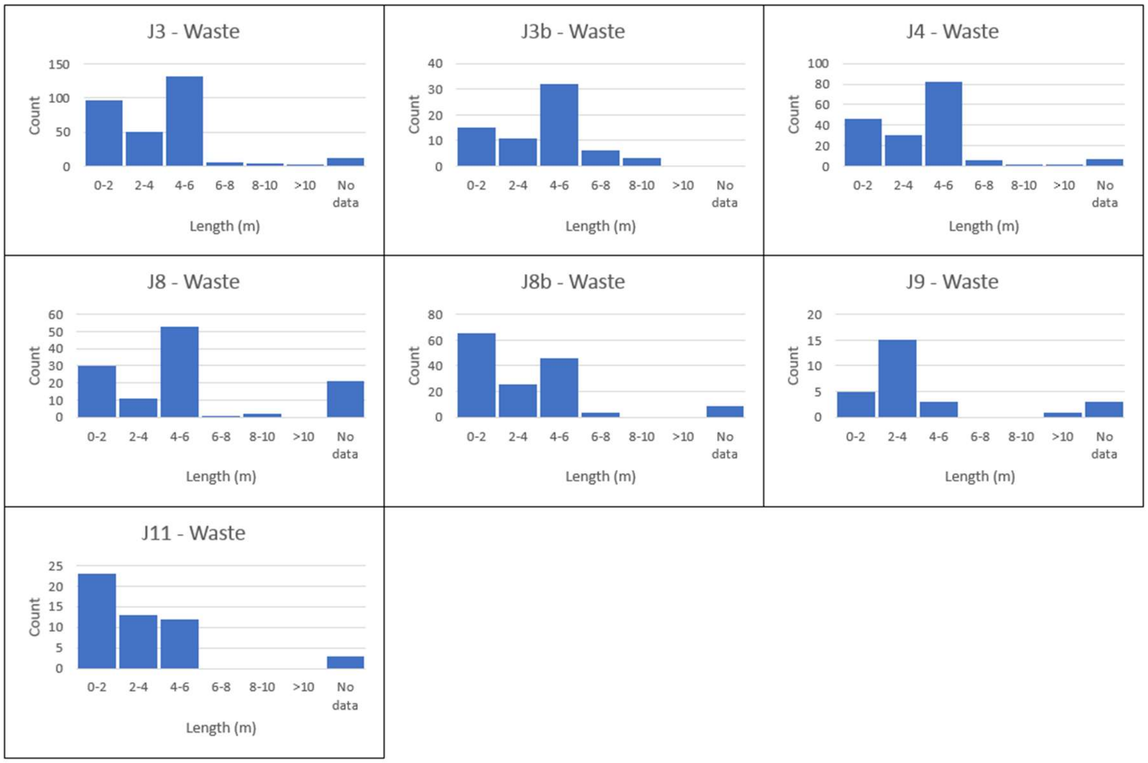


Figure 6: Mapping – Joint lengths in Waste

Direct shear testing on discontinuities was carried out in 2009 by SRK at the University of Arizona, summarized in Table 3. Due to the potential for blast damage around underground openings, the following shear strength values are used in kinematic assessments: 35° friction angle and 0 kPa of cohesion.

Table 3: Direct Shear Strength Testing on Discontinuities

Area	Drillhole ID	Depth	Lithology	Friction Angle	Cohesion (kPa)
Area 2	C09-03	162.55	Foliated Granodiorite (fG)	33.7	10.0
Area 118	C09-01	49.87	Porphyroblastic Granodiorite (pG)	40.7	21.6
Area 118	C09-01	103.00	Porphyroblastic Granodiorite (pG)	35.0	20.5
Area 118	C09-01	212.15	Porphyroblastic Granodiorite (pG)	33.4	1.3
Area 118	C09-02	211.14	Porphyroblastic Granodiorite (pG)	32.9	5.7
			Average	35.1	11.8
			Values used for analysis	35	0

2.2.3 Intact Rock Strength

Intact rock strength properties, summarized in Tables 4: and 5: are based on the results on drilling and testing carried out in 2009 (SRK), 2015 (SRK), 2015 (Golder), 2016 (Golder), and Golder (2017).

Table 4: Summary of Testing for Intact Strength Properties

Area	Lithology	Condition	UCS (MPa) (excluding invalid tests)				Young's Modulus (E) (GPa)	Poisson's Ration	Brazilian Tensile Strength (MPa)	Density (kN/m^3)
			tests	min	max	mean				
Area 2 Pit	Equigranular Granodiorite (eG)	Fresh	1	103	103	103	-	-	-	26.3
	Foliated Granodiorite (fG)	Fresh	4	94	173	122	47	0.23	7.6	26.4
	Porphyroblastic Granodiorite (pG)	Fresh	2	58	150	104	15	0.08	-	26.4
		Weathered	3	21	49	31	-	-	-	25.8
Area 118	Equigranular Granodiorite (eG)	Fresh	1	150	150	150	-	-	-	26.3
	Foliated Granodiorite (fG)	Fresh	8	86	165	125	67	0.30	-	26.6
	Porphyroblastic Granodiorite (pG)	Fresh	6	72	198	141	49	0.21	10.1	26.4
		Weathered	1	88	88	88	51	0.22	-	26.1
Area 2 UG	Equigranular Granodiorite (eG)	Fresh	2	103	111	107	-	-	-	26.5
	Foliated Granodiorite (fG)	Fresh	14	75	138	103	65	0.23	-	28.0
	Porphyroblastic Granodiorite (pG)	Fresh	1	88	88	88	-	-	-	26.6
Minto East	Equigranular Granodiorite (eG)	Fresh	3	89	132	122	-	-	-	26.5
	Foliated Granodiorite (fG)	Fresh	4	65	142	105	-	-	-	28.9
Copper Keel	Equigranular Granodiorite (eG	Fresh	8	-	-	114	85	0.34	-	26.5
Copper Keel	Foliated Granodiorite (fG)	Fresh	4	-	-	109	82	0.24	-	27.0

2.2.4 Rock Mass Classification

Rock mass properties, summarized in Table 5, are estimated from diamond drillhole data and geotechnical mapping. Mapping data appears to indicate higher rock quality than logging and is considered more representative of conditions experienced underground to date.

Table 5: Rock mass parameter summary for underground mining areas

Area	Source	Type	Condition	Number of Samples	RMR			Q' Range		
					min	max	avg	min	max	avg
Area 2 (M-Zone)	Underground mapping	fG	Fresh	92 m	55	92	77	0.8	50.0	9.6
Area 118	Core Logging (SRK)	eG,pG,fG	Fresh	334 runs	22	81	58	-	-	-
			Weathered	59 runs	21	72	51	-	-	-
Area 118	Underground Mapping	fG	Fresh	147 m	59	89	79	1.4	150.0	17.7
		eG	Fresh	204 m	65	92	85	2.6	50.0	17.5
Area 2 UG	Core Logging (Minto)	fG	Fresh	60 runs	70	89	72	33.8	300	45.4
		eG	Fresh	83 runs	65	94	69	11.5	150	23.4
Minto East	Core Logging (Minto)	fG	Fresh	22 runs	61	89	69	10.6	73.8	23.2
Minto East	Core Logging (Minto)	eG, Peg, pG	Fresh	96 runs	56	89	64	18.2	300	26.4
Copper Keel	Core Logging (Minto)	eG, fG	Fresh	75 runs	-	-	74	0.2	447	50.4
Copper Keel	Underground mapping	fG	Fresh	100 m	-	-	-	0.3	100	29
Copper Keel	Underground mapping	eG	Fresh	120 m	-	-	-	8	60	25

2.2.5 Minto East and Copper Keel geometry/excavation dimensions.

Table 6: Summary of Minto East geometry

Dimension	Minimum	Maximum	Average
Dip (degrees)	0	30	15
Elevation (m)	470	505	-
Depth (m)	278	325	-
Length along strike (m)	100	316	215
Thickness (m)	5	25	10

Table 7: Summary of Minto East excavation dimensions

Excavation	Maximum Dimensions	Comment
Waste development headings	5.0m W x 5.5m H	Includes ramps, level accesses, remucks
Ore development headings	6.0m W x 4.5m H	-
Pillars	Variable	-
Stopes	Variable	-
Raises	3 m diameter 1.4 m diameter	-

Table 8: Summary of Copper Keel geometry

Dimension	Minimum	Maximum	Average
Dip (degrees)	0	30	15
Elevation (m)	543	633	590
Depth (m)	220	285	255
Length along strike (m)	320	450	400
Thickness (m)	5	25	10

Table 9: Summary of Copper Keel excavation dimensions

Excavation	Maximum Dimensions	Comment
Waste development headings	5.1m W x 5.5m H	Includes ramps, level accesses, remucks
Ore development headings	6.0m W x 4.3m H	-
Pillars	Variable	-Average Pillar width is 6.0m
Stopes	Variable	-
Raises	2m – 3m square	-

2.2.6 In-Situ Stress

No in-situ stress tests have been carried out on site to date. The magnitude and orientation of the assumed horizontal stresses are based on conditions in western North America with the orientation of the maximum horizontal stress roughly perpendicular to the axis of the trend of the Dawson Range. The following assumptions have been used in geotechnical analyses (Golder, 2015):

- Vertical stress = depth * gravity * rock density (average 2650 kg/m3)
- Maximum horizontal stress = 1.75 * vertical stress, oriented NE/SW
- Minimum horizontal stress = 1.5 * vertical stress, oriented NW/SE

To date, there have been no signs of overstress or stress damage observed at Minto.

2.3 Hydrogeology

Inflows have been encountered in the main ramp, primarily in fault/fractured zones and near the footwall of the orebodies. Un-grouted diamond drill holes have occasionally been encountered which have produced inflows up to approximately 10 GPM.

The mine currently pumps out 700,000 m^3/year from the underground workings to the water tailings management facility.

Table 10: presents the rock mass permeability measurements completed by Golder (1974) and Golder (2017). The 2017 values indicate a higher permeability for both the fault associated zones and the fresh rock and will be used for planning purposes moving forward.

Table 10: Rock mass permeability values (Hatch, 2006 after Golder, 1974; Golder, 2017)

Lithology	Year	Range (cm/sec)		Design Values (cm/s)
		Lower	Upper	
Highly weathered—near surface	1974	9.0x10^-6	1.5x10^-4	5.0x10^-6
Highly weathered—fault associated	1974	5.3x10^-6	7.0x10^-6	6.0x10^-6
	2017	2 x 10^-7	5 x 10^-5	2.5 x 10^-5
Moderately weathered	1974	4.7x10^-6	8.4x10^-6 (1)	6.0x10^-6
	2017	-	5 x 10^-6	5 x 10^-6
Fresh rock	1974	1.5x10^-6	8.3x10^-6 (1)	3.5x10^-6
	2017	9 x 10^-6	2 x 10^-5	1.5 x 10^-5

Note 1: Excludes results from shattered zones

3 Design Criteria

3.1 Design References

Underground design parameters were developed based on analyses and inspections outlined in the following documents, the file location for these documents is shown in Appendix C.

- Geotechnical Inspection of Underground Workings At Minto Mine, Yukon (Golder, 2020)
- Copper Keel Preliminary Stability Assessment (Golder, 2020)
- ME NFold Pillar Stability Assessment (Golder, 2017)
- Underground Mine Development and Operations Plan (Minto, 2017)
- Area 2 Mining Stability Assessment Summary (Golder, 2016)
- Inspection of the Physical Stability of the Minto Mine Underground Ground Support System (Golder, 2016)
- Area 118 Plunge Mining Stability Assessment Summary (Golder, 2015)
- Longhole Open Stope Stability Addendum – Revised Mining Heights (Golder, 2015)
- Ground Control Management Plan Review (Golder, 2015)
- Minto Mine Underground Reserve Update Geotechnical Input (Golder, 2015)
- Geotechnical Characterization of Existing and Proposed Longhole Open Stope Mining Areas (Golder, 2015)
- Minto 118-Zone – 3DEC/DFN Analysis (Itasca, 2014)
- Minto 118-Zone – FLAC3D Analysis of the Longhole Base Case Option (Itasca, 2014)
- Structural Stability Analyses at Minto Mine (Itasca, 2014)
- Itasca Site Visit of April 2014 at Minto Mine (Itasca, 2014)
- Kinematic Analysis-Underground Excavations (Internal, 2014)
- Itasca Site Visit of October 2013 at Minto Mine (Itasca, 2013)
- Itasca June 2013 Site Visit at Minto Mine (Itasca, 2013)
- Report on the Itasca Site Visit of 26-28 February 2013 at Minto Mine (Itasca, 2013)
- Report on the Itasca Site Visit of 16-19 October 2012 at Minto Mine (Itasca, 2012)
- Minto Phase VI Underground Geotech Evaluation –Draft (SRK, 2012)
- Prefeasibility Geotechnical Evaluation, Phase IV (SRK, 2009)

3.2 Underground Mine Development and Design

3.2.1 Mining Method

The M-zone, Area 118 and Area 2 zones were all mined using a longhole open stoping method; the Copper Keel and Minto East zones are being mined in the same manner. All these ore zones can be described as lenses of foliated and variably migmatized metamorphic rocks bounded at their hanging wall and footwall contacts by equigranular, undeformed granodiorite (eG) host rock. The metamorphic zones are typically 5-30m thick and the grade within them varies from 0% to approximately 6% copper. These zones typically dip at 20° to 35°.

The mining method requires a series of parallel sill drifts to be developed along the strike of the deposit following the footwall contact. From these sill drifts, typically 6m wide and 4.1m high, a top-hammer longhole drill rig drills rings of 3” diameter up-holes into the deposit above, stopping at the hanging-wall contact.

To provide adequate void space for blasted muck when starting a new stope, 1.8m x 1.8m inverse raises are drilled. These are composed of six, 6-inch diameter reamed holes, which are left unloaded and surrounded by a pattern of eleven 3½-inch diameter blast holes. Generally, each stope is initiated with one or more rings of blast holes on either side of the inverse raise; subsequent blasts increase the number of rings fired simultaneously to take advantage of the void space in each block.

After drilling is completed, the rings are loaded, blasted, and then mucked out from the sill drift, which serves as a drawpoint. The average blast size is 8000 to 10,000 tonnes. Mucking is via remote-controlled load-haul-dump machines (LHDs); all stopes are non-entry from 5m to the open brow so that no personnel are exposed to the open stope.
Ore is trucked to surface along the main access ramp and out through the Minto South portal.

For the Area 118 zone and M-zone, production drift centerlines were 15m apart; from each 6m-wide sill drift, drill holes fanned out to blast a 10m wide stope. 5m-thick rib pillars separated each stope thus supporting the hanging wall.
For the Area 2 zone and Minto East, production drift centerlines were/are 20m apart. Stope and pillar widths vary based on the ore thickness (stope and pillar height). Typical stope widths were/are 15m and typical pillar widths were/are 5m.
For Copper Keel, production drift centrelines are 20m apart. Stope widths are15m wide and pillar widths are 6m wide.
For more details on the stope geometry see Section 3.2.4
Significant variability in copper grade occurs within each ore zone; therefore, core drilling completed as part of earlier exploration is supplemented by infill drilling done from each sill using the production drilling equipment.
In the Area 118, Area 2 and Copper Keel zones additional core drilling was also done from within the underground workings.

The mining method does not use backfill; however, small quantities of development waste are sometimes placed in completed stopes to reduce haulage requirements.

3.2.2 Mine Access

The main ramp of the Minto South Underground measures 1,677m, extending to Area 2, 630 level. The access to Copper Keel is at 1960m and the designed length of Copper keel ramp is 431m. The first access to the current Minto East zone is 2,440m in length. The upper ramp is 5.0m wide and 5.0m high; the ramp below the 690 level was driven at dimensions of 5.0m wide and 5.5m high to provide additional clearance between vent ducting and haul trucks. This access is used for all ore and waste haulage, personnel/equipment access and services. Re-muck bays were developed every 150 m along the decline to improve the efficiency of the development cycle; they were designed to hold two rounds of development muck. The re-muck bays have the same dimensions as the decline and are generally 15 m in length. They have since been repurposed as equipment storage, pump stations, drill bays, service bays, etc.

Ground support generally comprises 2.4m-long, 12T inflatable bolts on a 1.5m x 1.5m diamond pattern around the whole excavation, or 2.4m-long fully grouted resin rebar bolts on a 1.5m x 1.5m pattern with a 1.8 m bolt in the center for the back and 1.8m bolts for the walls. Welded wire screen is installed to within 1.5 m from the floor. Additional support in the form of 3.6m, 24T inflatable bolts are installed at all drift intersections and areas of wider than planned span or challenging ground conditions.

3.2.3 Longhole stoping

Stope spans for mining areas were designed using a combination of empirical analysis, numerical modelling and experience in the Minto underground to date. Examples of stability graphs for the Area 2 and Minto East deposits are shown in Figures 7 and Figure 8 respectively.

Exposures plot in the stable or transition zone with less than 2m of equivalent linear overbreak/slough (ELOS).

To date, no unmanageable instability has been experienced in open stopes. Stope backs have performed well, typically breaking clean to a planar, discrete hanging wall contact. In Copper Keel, stope 5726 experienced overbreak (Aug 2020) in the back which arched over the pillar to 5724. The overbreak was associated with localized structures. The subsequent stop pillar widths were increased, and control of the stope behaviour was regained.

Typical overbreak in stope backs is less than 0.5m and underbreak from the planned back is more common.

Several trial stopes were mined in Area 118 to investigate the performance of wider spans. These included four areas in different parts of the deposit successfully mined at widths up to 20m, with little to no overbreak.

Instability in the stope walls has occurred in several places where fault zones result in weak, ravelling type behaviour. Unplanned pillar breakthroughs occurred in two places in Area 118.

In the MZone, two pillars unravelled for approximately 30-40m in length. In all cases, pillars were successfully re-established either by narrowing the subsequent stope blasts or re-slotting to leave a mid-stope pillar.

The mining method allows for flexibility to adapt to changing conditions by leaving wider pillars or mid-stope pillars as conditions dictate.

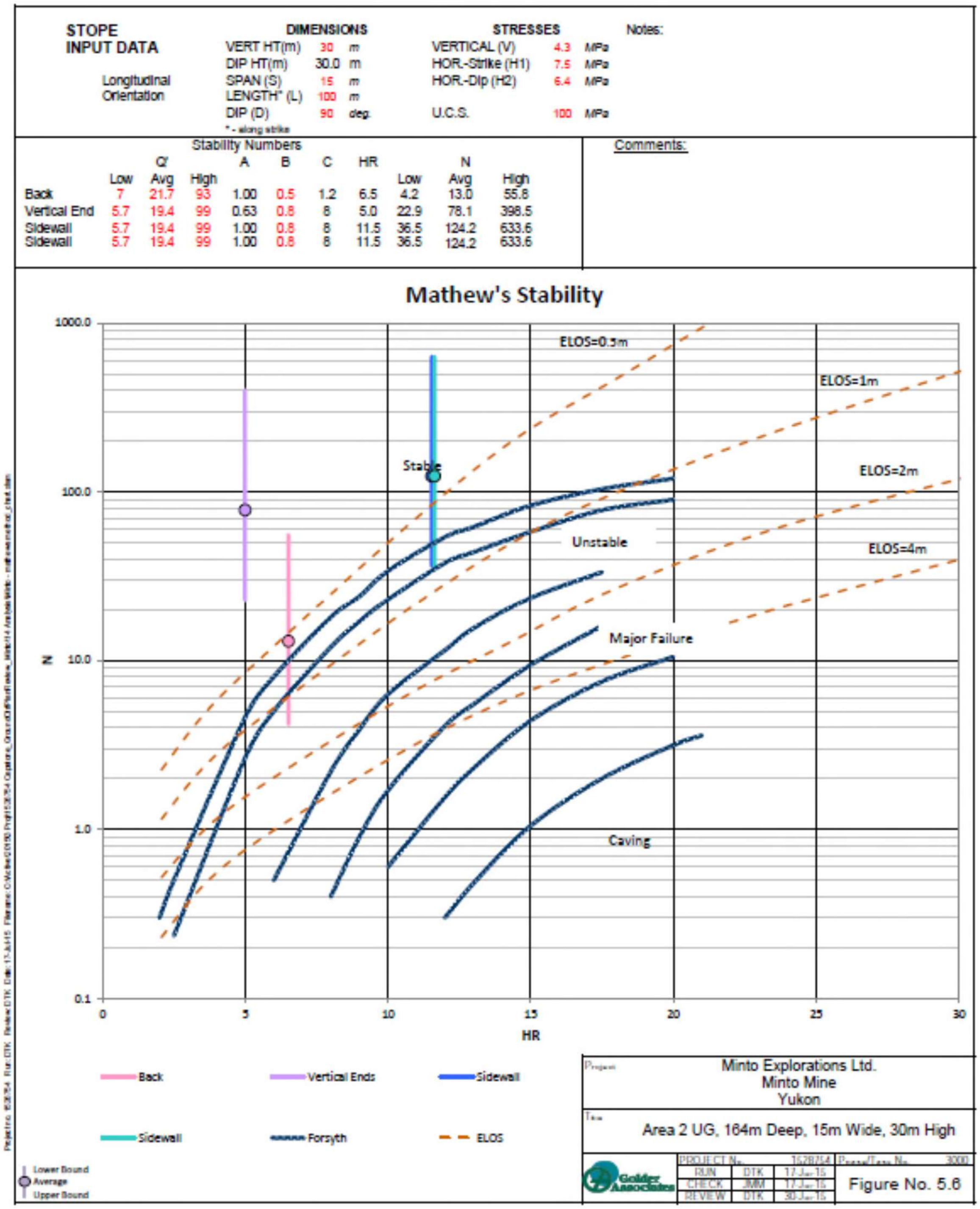
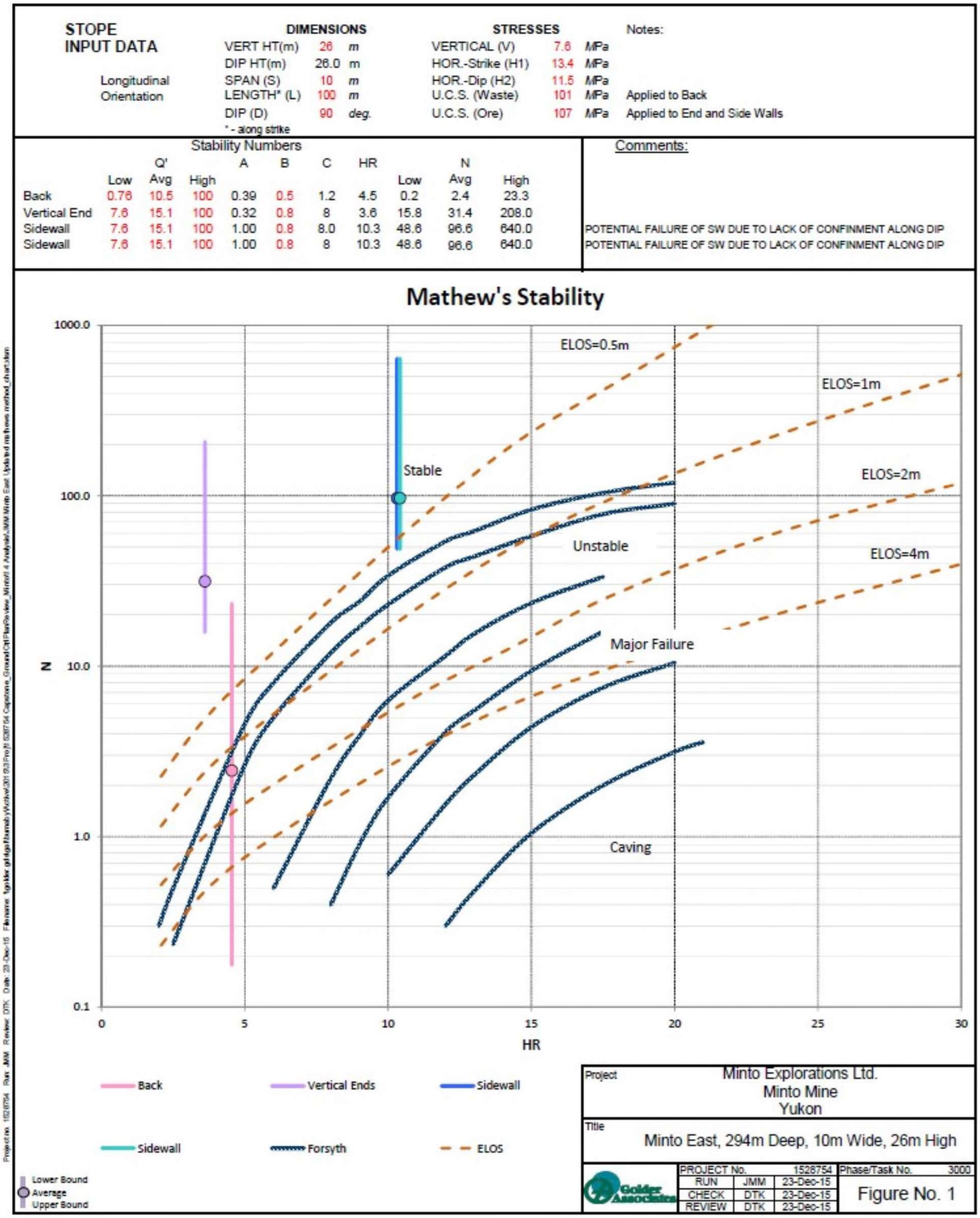


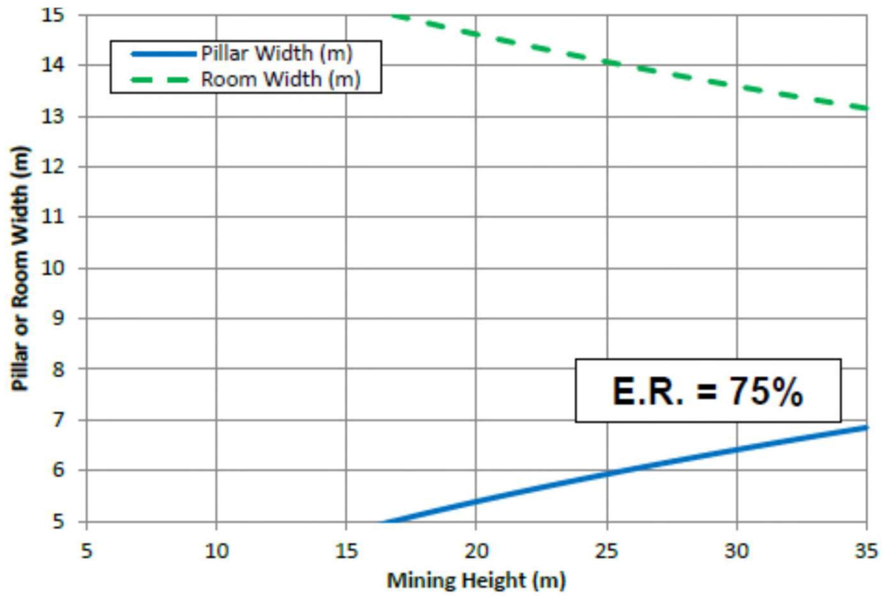
Figure 7: Area 2 Stability Graph Analysis (Golder, 2015)



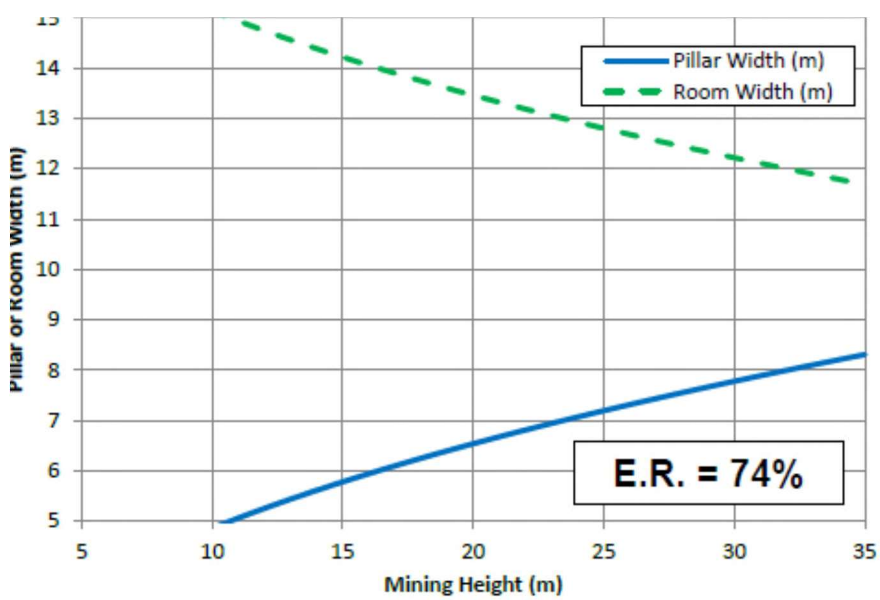
	Q' Low	Q' Avg	Q' High	A	B	C	HR	N Low	N Avg	N High
Back	0.76	10.5	100	0.39	0.5	1.2	4.5	0.2	2.4	23.3
Vertical End	7.6	15.1	100	0.32	0.8	8	3.6	15.8	31.4	208.0
Sidewall	7.6	15.1	100	1.00	0.8	8.0	10.3	48.6	96.6	640.0
Sidewall	7.6	15.1	100	1.00	0.8	8	10.3	48.6	96.6	640.0

Figure 8: Minto East Stability Graph Analysis (Golder, 2016)

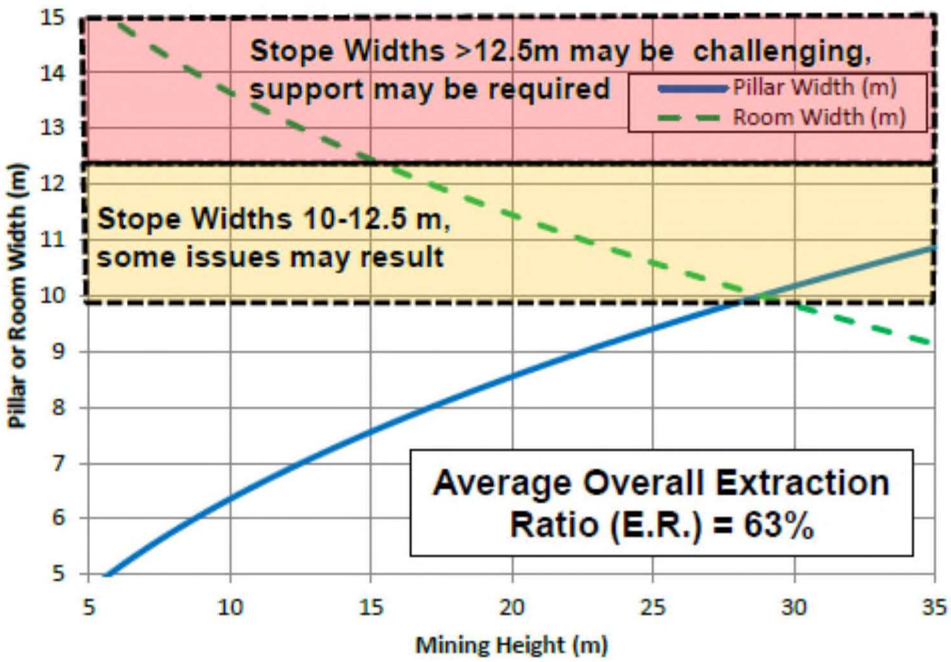
Empirical and numerical analyses were carried out by Golder Associates Ltd (Golder) to assess the Area 118, Area 2, Minto East and Copper Keel zones. Complete results are contained in the reports titled: “Minto Mine Underground Reserve Update Geotechnical Input” (Golder, 2015) and Copper Keel Preliminary Stability Assessment (Golder, 2020). Permissible stope and pillar widths were estimated for the range of mining heights in each deposit, shown below for Area 2 and Minto East. Copper Keel is mined within these stope parameters.



Empirical analysis results for Area 2 upper lens (650 level)



Empirical analysis results for Area 2 lower lens (630 level)



Empirical analysis results for Minto East

3.2.4 Stope Layout

Fig 9: shows a perspective view of the Minto East stope design looking southwest. The zone is a single lens, and is developed from east to west, then is retreated in the opposite direction.

Fig 10: shows a plan view of the Copper Keel stope design

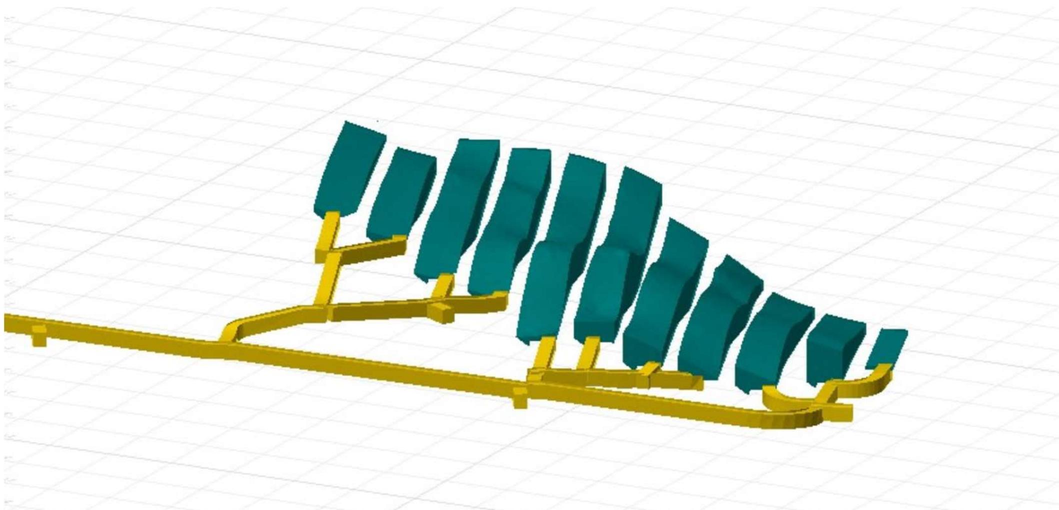


Figure 9: Perspective view of the Minto East stope design

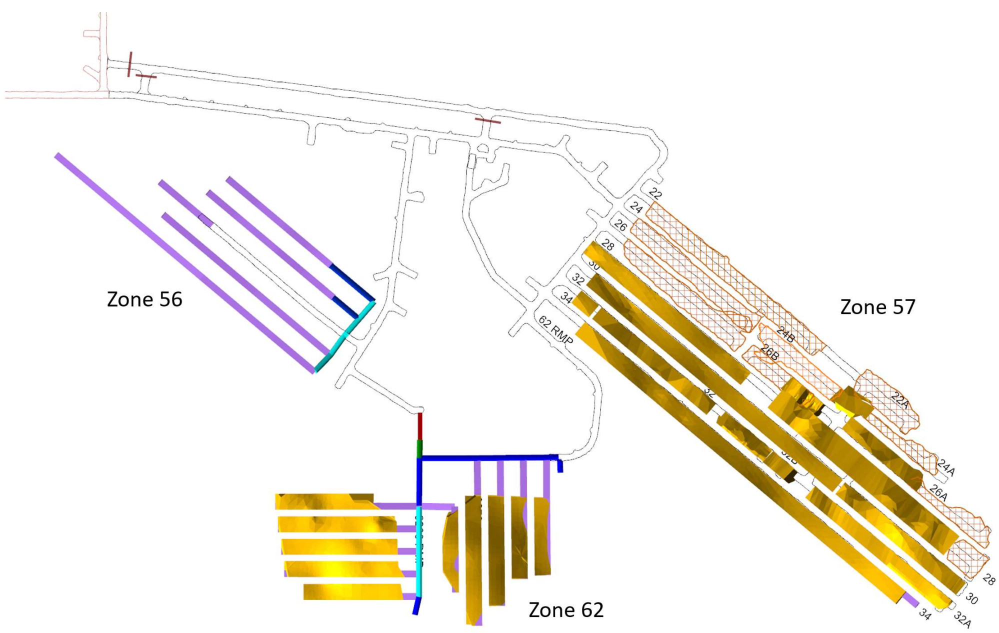


Figure 10: Plan view of the Copper Keel stope design

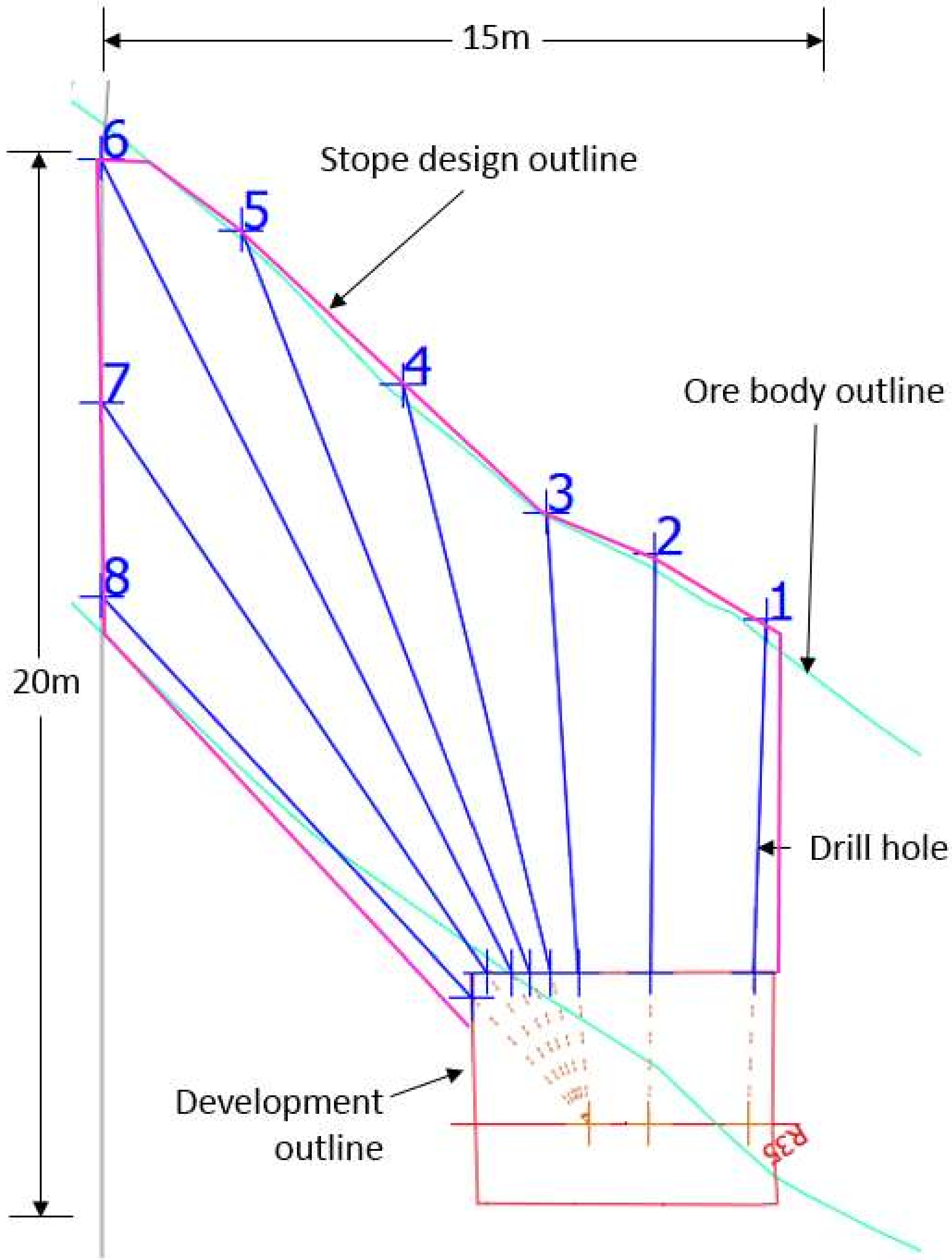


Figure 11: Typical stope layout

3.2.5 Material Handling

A combination of 8 yard and 10-yard LHD units mucking into 42 and 45 tonne trucks are used for ore and waste haulage. The broken ore from the stopes is mucked by LHDs to remuck bays, or loaded directly onto trucks, which carry ore from the mine to a small stockpile adjacent to the portal. The surface mining fleet then takes ore to a stockpile then sent to the mine crusher daily.

Waste rock from development headings is either hauled to surface in the same manner or trammed to a mined-out stope and dumped there. Development rounds are assayed, and the waste is moved to the appropriate waste dump as outlined in the Waste Rock and Overburden Management Plan (WROMP) (see Appendix C for document location). The protocols for segregation and placement of waste materials are consistent with the protocols for surface mining.

3.3 Ground Support Design

Ground support design is carried out using a combination of empirical and kinematic analyses, and experience to date at the Minto Mine site. Assessments of geotechnical characteristics of the underground workings and performance of the ground support system are done during regular inspections, mapping and QA/QC tests of support elements. Analysis is updated as part of the annual GCMP update and performed throughout the year as required. For kinematic analysis, wedges with an apex height taller than half the span are locked in by clamping stresses. The file location of the kinematic analyses can be found in Appendix C.

3.3.1 Ground Support Elements

Details and specifications of ground support elements used in standard support patterns at Minto are listed below in Table 11: Ground Support Elements.

Table 11: Ground Support Elements

Support Element	Description	Minimum Breaking (tensile) Strength	Comment
Bolts	12T Standard Swellex (27 mm)	12 tonnes	Used for development bolting.
	24T Super Swellex (36 mm)	24 tonnes	Used for brow support and additional support at intersections or large spans.
	#6 (20mm) (3/4") threaded rebar bolt w/ full column resin	13 tonnes	-
	#6 (20mm) (3/4") forged head rebar bolt w/ full column resin	18 tonnes	-
	Split-sets (35 mm)	6 tonnes	Used for face bolting or pinning screen.
Plates	Domed - 15 x 15 cm (6" x 6"), 6 mm (1/4") Flat - 12.5 x 12.5 cm (5" x 5"), 6 mm (1/4")	5 tonnes	-
Resin	30mm x 610mm cartridges 30 second (fast) 180 second (slow)	-	-
Mesh	6 gauge welded wire mesh	~ 2-3 tonnes bag strength	Galvanized or Bright depending on the use of the excavation.
Straps	0 gauge welded wire mesh straps	-	Used for stope brow support and additional pillar support where required.

3.3.2 Ground Support Standards

Support standards for development and production headings have been developed for three types of ground, as summarized in Table 12: below. Detailed ground support drawings are provided in Appendix A. Ground support standards are communicated on design prints. Ground support for excavations not included in the GCMP, including vertical development, is designed on a case-by-case basis and issued by the Geotechnical Engineer as a Ground Control Directive.

The ground support types outlined below are typical standards - supervisors and workers installing the ground support should assess the conditions and place additional ground support over and above that stated as conditions dictate. A note detailing the reason why the extra support was required, and the type and location of the extra ground support is added to the Ground Control Logbook and communicated to the Geotechnical Engineer during the daily production meetings.

Table 12: Typical Ground Support for Development and Production Headings

Type		**Span (m)**	**Primary Support (typical)**	**Comment**
1	**Development Drifts (typical ground conditions)**	5.1	2.4 m 12T Standard Swellex bolts only, or 2.4 m resin rebar in back around perimeter of mesh sheets 1.8 m resin rebar in back and walls to pin mesh at center 1.8 m resin rebar in walls to 1.5 m above floor 1.5 m x 1.5 m bolt spacing in a diamond pattern 0.9 m Split-sets (35 mm) Used for pinning screen only Welded wire mesh to 1.5 m above floor	Life of mine infrastructure in typical ground conditions. Overlap mesh by three squares.
2	**Production Drifts (typical ground conditions)**	6.0	2.4 m 12T Standard Swellex bolts only, or 2.4 m resin rebar in back around perimeter of mesh sheets 1.8 m resin rebar in back and walls to pin mesh at center 1.8 m resin rebar in walls to 1.5 m above floor 1.5 x 1.5 m bolt spacing in a diamond pattern 0.9 m Split-sets (35 mm) Used for pinning screen only Welded wire mesh to 1.5 m above floor	Non-permanent development (e.g. stope undercut drifts) in typical ground conditions. Overlap mesh by three squares.
3	**Poor ground – fault zones**	≤6.0	2.4 m 12T Standard Swellex bolts only, or 2.4 m resin rebar in back around perimeter of mesh sheets 1.8 m resin rebar in walls to 1.5 m above floor 1.5 x 1.5 m bolt spacing in a diamond pattern 0.9 m Split-sets (35 mm) Used for pinning screen only *Additional*: 3.6 m, 24T Super Swellex, diamond pattern, 1.5m x 1.5m centers Welded wire mesh to 1.5 m above floor	Poor ground, typical in fault zones. Overlap mesh by three squares.
Intersection Secondary Support				
1,2,3	**Intersections**	≤9.5*	To be installed in addition to the primary support pattern outlined above: 3.6 m 24T Super Swellex in back and shoulders 1.5 x 1.5 m bolt spacing - Installed at least one row past the intersection in each direction.	Intersection support to be installed prior to taking wall slash, as per MIN-OP-SWP-005 Underground Intersection Development and Ground Support

*Intersection spans are measured using the inscribed circle method.

Intersections are preferentially located in areas of good ground conditions. If an intersection must be developed in an area of poor ground, a specific ground support design will be completed by the Geotechnical Engineer and issued as a Ground Control Directive. Ground Control Directives are filed electronically, file locations can be found in Appendix C. Where as-built surveys indicate an intersection has broken to a span greater than 9.5 m, the Geotechnical Engineer or their designate will conduct an analysis of the intersection to determine whether the standard ground support is adequate. If the findings of the analysis confirm that additional support is required a Ground Control Directive will be issued. These analyses are digitally filed; location listed in Appendix C.

Longhole stopes are pre-supported at the stope brows with secondary support in addition to the standard development support. Four types of brow support are outlined in Table 13: Where jumbo holes are to be loaded, brow support will continue down the wall as outlined in the “Type A Modified” and “Type B Modified” brow plans listed in Table 13. The Geotechnical Engineer will specify which support type to install for each brow and a brow support print will be issued. Supervisors and workers installing the ground support should assess the conditions and may install additional ground support over and above that stated as conditions dictate.

Table 13: Ground Support Standards for Open Stope Brow Pre-Support

Type		**Drift Span (m)**	**Brow Pre-Support**	**Comment**
A	**Stope Brow in Normal Conditions**	≤6.0	3.6 m (12 ft.) 24T Super Swellex - 1 row at 1.5 m spacing 0-gauge welded wire mesh straps	Used in normal ground conditions.
A-Modified	**Stope Brow in Normal Conditions with jumbo holes**	≤6.0	3.6 m (12 ft.) 24T Super Swellex - 1 row at 1.5 m spacing – row continuing down wall to jumbo holes 0-gauge welded wire mesh straps	Comments same as for **Type A**.
B	**Stope Brow in Fractured/Fault Zone**	≤6.0	3.6 m (12 ft.) 24T Super Swellex - 2 rows at 1.5 m spacing 0-gauge welded wire mesh straps on the brow row only	Used where continuous fractures, faults or highly fractured ground is encountered at the planned stope brow.
B-Modified	**Stope Brow in Fractured/Fault Zone**	≤6.0	3.6 m (12 ft.) 24T Super Swellex - 2 rows at 1.5 m spacing – rows continuing down wall to jumbo holes 0-gauge welded wire mesh straps on the brow row only	Comments same as for **Type B**

Part Two: Implementation

4 Ground Support Installation

All operators must be trained, qualified and authorized to use the ground support installation equipment.

Ground support installation specifications are summarized in Table 14.

Table 14 Ground Support Installation Specifications

Support Element	Hole Diameter	Inflation Pressure	Comment
#6 (20mm) (3/4") threaded rebar	26 – 33 mm	-	Hole length 10cm (4") shorter than bolt length. Rebar are installed with a torque tension (TT) shear pin nut to allow resin mixing and torquing in the same direction. 6 ft. long rebar - 1 fast resin and 2 slow resin. 8 ft. long rebar - 1 fast resin and 3 slow resin.
12T Standard Swellex	33 – 38 mm	4350 psi (300 bar)	-
24T Super Swellex	43 – 52 mm	4350 psi (300 bar)	-
Spilt-sets	33 mm 33 – 45 mm	- -	Min 3ft long, used for pinning screen only. Min 8ft long for pinning screen to face when face bolting.
Welded wire mesh	-	-	Screen overlapped by 3 squares, with bolt placed in second square from the edge.

5 Scaling

Scaling will only be undertaken by individuals that have undertaken hazard recognition training and who have been trained and certified in scaling procedures.

Appropriate length scaling bars are available on specified machines and located where required.

6 Rehabilitation

Areas requiring rehabilitation are identified during regular inspections by the Mine Technical team and by the workforce/supervisors who record the information in the Ground Control Logbook. Rehabilitation prints are generated by the Geotechnical Engineer and are issued to the Shifters and Superintendent. A electronic copy of the prints is kept by the mine technical dept. Once rehabilitation has taken place, the area is inspected by the Geotechnical Engineer or designate to ensure it is to standard.

7 Risk Assessment and Management

7.1 Hazard Recognition Training Program

Hazard recognition training is conducted during orientation for every person working underground at Minto. This training is mandatory and applies to new employees as a condition of employment. Specific training modules for scaling and ground support are presented at these sessions.

7.2 Hazard Recognition Responsibilities

The following are regulations specific to hazard recognition in the Yukon Occupational Health and Safety Regulations (in effect from May 11, 2006).

Notice of hazards 15.12

> (1) Where there is a non-continuous shift operation at a mine or project, the on-coming shift shall be warned of any abnormal condition affecting the safety of workers.
>
> (2) The warning referenced in subsection (1) shall consist of a written record in a log book under the signature of the person in charge of the off-going shift and be read and countersigned by the person in charge of the on-coming shift before the workers are permitted to assume operations in the area indicated in the record.
>
> (3) The log book referred to in subsection (2) shall be available on request to a joint health and safety committee representative, if any, and to a safety officer.

Underground Support 15.48

> (1) Every adit, tunnel, stope, or other underground opening, where a worker may be exposed to the danger of rock fall or rock burst while working or passing through, shall be supported by wooden or steel support structures, casing, lining, rock-bolts or combination of any of these to make the openings secure and safe.

Potential rock burst

(2) Where ground condition indicates that a rock burst or uncontrolled fall of ground may occur, the condition and the corrective action taken shall be recorded in writing in the daily logbook and signed by the shift supervisor.

Work areas examined

(3) A competent person shall examine all working sections of an underground mine or project at least once during each shift.

Non-work areas examined

(4) Non-working sections of an underground mine or project that are not barricaded or to which access is not prevented shall be examined at least once a month.

Scaling tools

(5) An adequate quantity of properly dressed scaling bars, gads, and other equipment necessary for scaling shall be provided in working sections.

7.3 Ground Control Communication

Communication of ground control issues and concerns among technical, operational and management staff, and between shifts takes place at several levels and includes:

- Shift boss logbook.
- Ground control logbook.
- Face to face meeting of the shift supervisors between shifts.
- Verbal communication by the crews at shift change.
- Daily production meetings, and weekly planning meetings, attended by the Underground Superintendent and Minto engineering and management staff.
- Ground control directives issued by the Geotechnical Engineer; and,
- Survey prints showing adverse structure.

7.3.1 Review of Design Guidelines

Mine plans are reviewed by the Geotechnical Engineer or designate to assess expected geotechnical conditions and ground control aspects in the planned excavations, considering the geotechnical data and inspections/mapping carried out. Survey prints of planned excavations with prescribed ground support are signed off on by the Geotechnical Engineer or designate prior to mining of the heading. Where significant geotechnical conditions are expected, e.g., fault zones, contacts, water-bearing zones, they are to be shown on the survey prints.

7.3.2 Unusual Ground Conditions

The intent of the current Ground Control Standards as outlined in this document are that all expected ground conditions are addressed. In the event conditions beyond those covered in the current version of the Ground Control Standards are encountered by an operator or anyone doing a routine inspection, the area shall be roped off immediately and brought to the attention of the Supervisor. The Supervisor shall notify the Geotechnical Engineer who will inspect the area and develop a path forward. The condition and findings must be documented in the Ground Control Logbook.

7.4 Incident Response and Emergency Preparedness

The Minto Mine Emergency Response Plan documents the incident response and emergency preparedness procedure. This plan is updated annually by the Minto Health and Safety Department.

7.4.1 Falls of Ground

All rock fall incidents are documented in the Ground Control Logbook. Reportable rock falls are considered unexpected falls greater than 50 tonnes within a man-entry excavation and are fully investigated, reported to Yukon Workers' Compensation Health and Safety Board (YWCHSB) and archived as per Minto incident response procedures.

Details of all reported falls of ground will be recorded electronically in a rock fall database, maintained by the Geotechnical Engineer. The following items are recorded:

- General information: location, date and time, injuries, damage
- Location: depth below surface, excavation type, distance from active face
- Excavation details: age of excavation, dimensions, excavation shape
- Geotechnical conditions: rock quality, structure, water inflows
- Ground support details: implemented support standard, rehabilitation.
- Failure details: dimensions, failure mechanism, types of ground support failure
- Potential contributing factors: ground support, blasting, stress, ground condition, human factor
- Personnel exposure: time of occurrence, activity in area
- Possible preventative actions.

To date, no unexpected falls of ground have occurred in Minto underground development.

8 Workforce Training

Underground mining is currently being carried out by a mining contractor. Workforce training consists of Minto safety training, Safe Work Practices (SWP’s), and Safe Job Procedures (SJP’s).

8.1 Safe Work Practices (SWP’s) and Safe Job Procedures (SJP’s)

It is a requirement that employees and contractors be trained in the use of relevant Safe Work Practices (SWP’s) and Safe Job Procedures (SJP’s) that apply to their work environment. All SWP’s/SJP’s required for the work are reviewed and signed off by the employees upon induction to the Minto mine site. SWP’s/SJP’s are linked to and used in competency-based training programs. Employees are assessed in the workplace periodically on their understanding and compliance with SWP’s/SJP’s using Planned Job Observations (PJO’s) performed by the supervisor.

8.2 Training of Workforce

Training is presented to the general underground workforce by their supervisor at Minto Mine. This training is site specific and includes identification of ground types, structural features such as wedges and blocks, recognition of loose, scaling, minimum support standards and reporting unusual conditions.

8.3 Training of Supervision

Training is presented to underground supervisors by the Geotechnical Engineer or designate. This training is site specific and covers all areas pertinent from a supervisory point of view such as: selection of support types, dealing with unusual ground conditions and supervisory reporting requirements in addition to the general training to be provided to the mining workforce.

Part Three: Monitoring and Verification

9 General Practices and Procedures

9.1 Ground Inspections

All underground workers will inspect the ground conditions each time the workplace is entered as per the Minto Mine 5 - point safety card system. Unusual conditions such as falls of ground, excessive loose, adverse structures, signs of high stress, or ground support damage must be noted and reported to the supervisor.

Routine ground inspections will be conducted by the Geotechnical Engineer and/or Chief Engineer to assess the stability of mine openings, ground support performance and the quality of ground support installation. A report with the findings from the routine ground support inspections will be prepared by the Geotechnical Engineer and distributed to the Mine Technical Department and contractor supervisors. The file location where these inspection reports are kept can be found in Appendix C.

An annual inspection of ground support conditions shall be conducted by an external consultant. The file location where these inspection reports are kept can be found in Appendix C.

9.2 Ground Control Logbook

The Ground Control Logbook is maintained as a live record of ground control related issues such as unusual conditions, falls of ground, incidents or accidents, remedial measures, problems with support consumables etc. This ensures the transfer of information between shifts and Engineering/Technical staff. The Ground Control Logbook is to be updated and signed by both the finishing and oncoming shifter when details of concern are logged. This is then reviewed/signed by the Geotechnical Engineer or designate. The details of concern are investigated by the Geotechnical Engineer or designate and agreed remedial actions entered in the logbook.

9.3 Geotechnical Mapping

Geotechnical mapping for rock quality and rock structure is carried out to verify rock mass characterization assumptions (summarized in Section 2) used in the geotechnical design. This is performed in the field for development drifts and using digital mapping software for stope mapping. This data is reviewed regularly to identify significant geotechnical features and is summarized and analyzed annually as part of the Ground Control Management Plan update. The file location of where the geotechnical mapping is stored can be found in Appendix C.

9.4 Excavation Surveys

Regular surveys of all workings are carried out and transferred to as-built drawings. This provides an estimate of over-break which may indicate poor ground conditions or poor drilling/blasting practices.

Cavity monitor surveys (CMS) are performed on all open stopes. If analysis shows deviation from that planned, subsequent stopes are adjusted to achieve the designed pillar sizes/shape.

9.5 Instrumentation

No geotechnical instrumentation is currently installed underground. It is planned to install sloughmeters in the near future above the left-hand pillar of 5728 to monitor pillar conditions as the stopes retreat.

10 Quality Assurance/Quality Control

10.1 Ground Support Testing

Testing of ground support elements is carried out when development is taking place according to Table 15. Only suitably trained personnel who have been trained and signed off on the applicable SWP may carry out ground support testing under the supervision of the Geotechnical Engineer.

Table 15: Ground Support Testing and Specifications

Element	Ultimate Strength (tonnes)	Yield Strength (tonnes)	Average Bond Strength (based on testing to date) (tonnes/m)	Testing Method	Test Load (tonnes)
20mm threaded rebar w/ resin	13	9	40	Pull test—full column	8
				Pull test—short encapsulation	Until bolt slippage
12T Standard Swellex	12	9	8	Pull test—full inflation	8
				Pull test—partial inflation	Until bolt slippage
24T Super Swellex	24	-	26	Pull test—full inflation	20
				Pull test—partial inflation	Until bolt slippage

10.1.1 Test Bolt Installation

Bolts for pull-testing are installed by the bolter operator according to the following guidelines:

- Installed and marked specifically for testing purposes and as such are not part of the regular ground support pattern.
- Installed in the lower wall to allow pull testing to be carried out safely from floor level.

- Installation locations are painted by the Geotechnical Engineer and preferentially located in safety bays or cut-outs to allow testing to be carried out safely away from equipment traffic.
- Installed in both ore and waste, and in varying rock type/quality where applicable.
- For bond strength tests (short encapsulation/inflation), the following specifications are used:
  - Rebar – resin encapsulation length less than approximately 30 cm, installed at the toe of the hole. This requires only ½ stick of fast resin to be installed. The remainder of the hole is filled with sticks of inert test resin.
  - Swellex/Super Swellex – inflation length less than approximately 0.6 m, inflated at the toe of the hole. The remaining length at the collar of the hole is sleeved to prevent inflation.

10.1.2 Pull Test Procedure

Pull tests are conducted according to the SWP ENG-SWP-010 Rock Bolt Pull Testing. If tests fail to meet the set criteria, further tests will be conducted to verify that the problem is not widespread. If the problem is widespread, the area will be shut down and an investigation will be carried out by Minto Mine Technical Services to ascertain the cause of the failures and develop rehabilitation/corrective actions.

10.1.3 Documentation

Records of all tests are documented in a master Excel spreadsheet and a monthly report is produced; the file location is listed in Appendix C. Information recorded includes bolt type, location, rock type, test result and description. A memorandum is issued communicating abnormal test results and pertinent information to Minto Mine Technical and underground operations staff.

10.2 Ground Support Quality Assurance / Quality Control

10.2.1 Materials Management

Regular checks are required to ensure that all ground support materials are of a suitable standard and quality, fit for intended purpose, and are stored in accordance with manufacturers' recommendations.

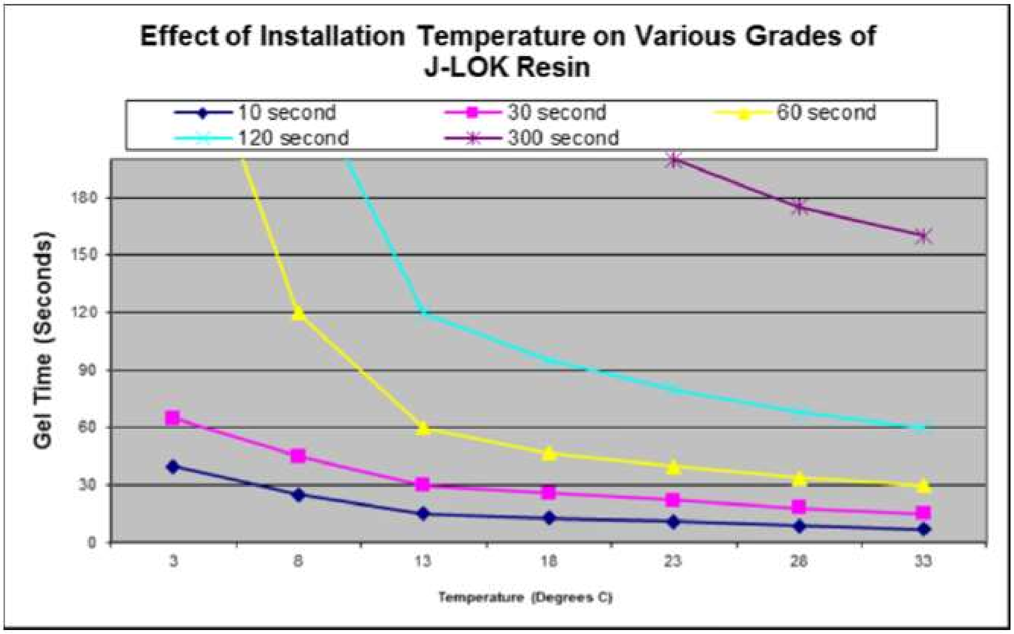
<u>Resin Storage and Handling</u>

The most sensitive ground support element is resin which should be stored and handled with the following guidelines:

- Resin should be stored in a cool and dry location, avoiding direct sunlight and rain. Excessive heat reduces the shelf life of the resin.

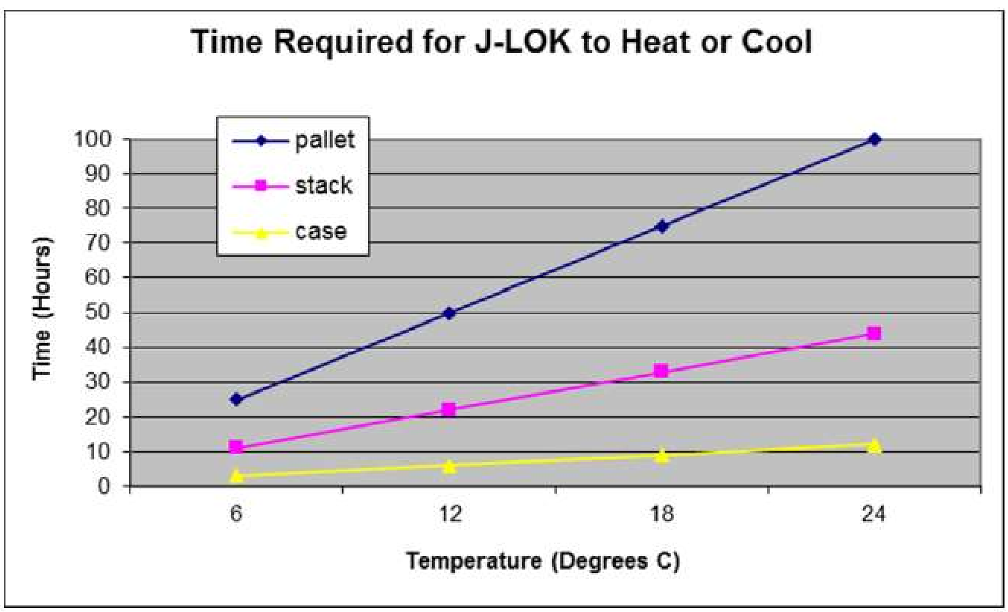
- Stock must be rotated. The resin that is first in should be first out. Out-dated resin should not be used. Resin typically has a one-year shelf life, but 1-2 month inventories are the best way to manage resin.

- Resin performance is highly sensitive to installation temperature.



- Underground, resin boxes should be laid flat, not stood on end. The resin should be moved from storage directly to the machine.

- Frozen cartridges must be thawed before being used. Freezing and thawing does not affect the performance of the resin. Resin boxes should not be left on top of hot locations for extended periods.



- Wear gloves and glasses when working with resin products. Upon contact with skin, wash exposed area immediately. If there is contact with the eyes, flush thoroughly and seek immediate medical counsel and treatment.

10.2.2 Task Observation

Task observations are carried out on ground support installation on a regular basis (minimum one per month) by the Ground Control Engineer. The location of where the completed inspection forms are stored is listed in Appendix C. Any findings will be communicated through Ground Control Directives. Typical verification checks include:

- Confirm screen overlap is adequate.
- Visual check of adherence to bolting pattern as per ground support standard.
- Check that adequate scaling is carried out prior to ground support installation.
- Check that the bit size is within the recommended size range.
- Check of Swellex pump pressures.
- Check that correct resin cartridges are being used (fast vs slow).
- Observe bolt spin time and delay time prior to tensioning.
- Check of rebar tensioning torque.

11 Review of the Ground Control Management Plan

11.1 Review and Updates

The Mine Manager/Chief Engineer will ensure a review of the Ground Control Management Plan at the following milestones/occurrences:

- Immediately following a ground control related injury to any employee/contractor/visitor;
- Immediately following a ground control related near miss incident;
- As soon as possible following any significant change in mine design, support design/consumables, ground conditions or excavation stability; and,
- Annually.

The Mine Manager/Chief Engineer will ensure that the review/update is carried out by a suitably qualified person.

Following a review of the Ground Control Management Plan, the Mine Manager/Chief Engineer (or designate) will ensure the review outcomes are communicated to the workforce and the Ground Control documentation is updated in a timely manner.

11.2 Random Audits

Random audits of ground control are conducted by the Geotechnical Engineer or nominee to monitor compliance with the requirements of the Ground Support Standards and Safe Work Procedures.

11.3 External Audits

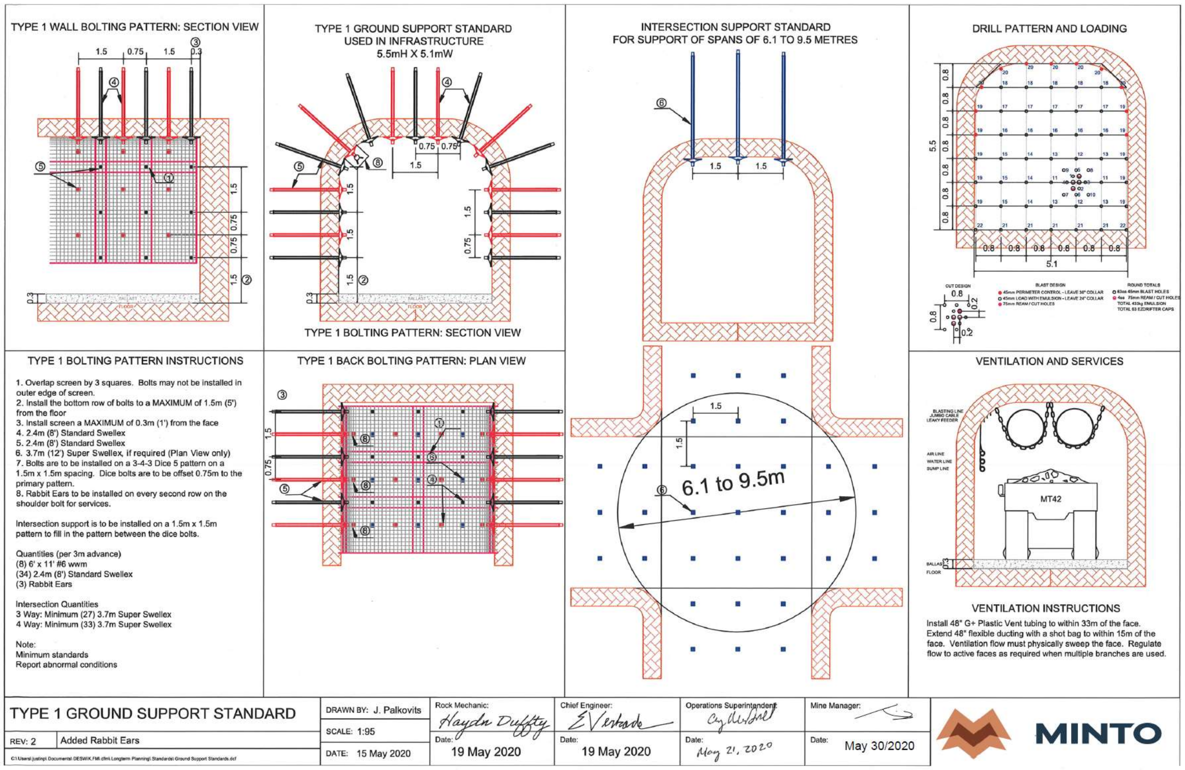
An independent audit of the Ground Control Management Plan is required at least every year.

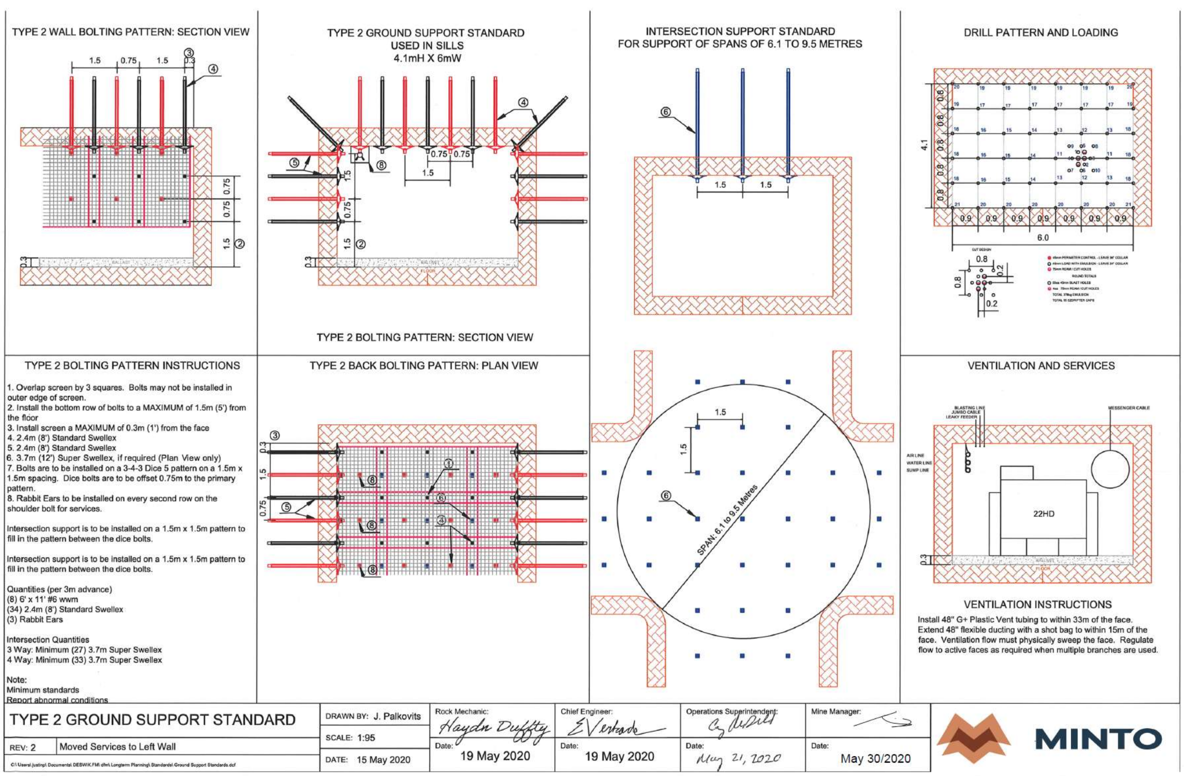
11.4 Conformance to Regulatory Requirements

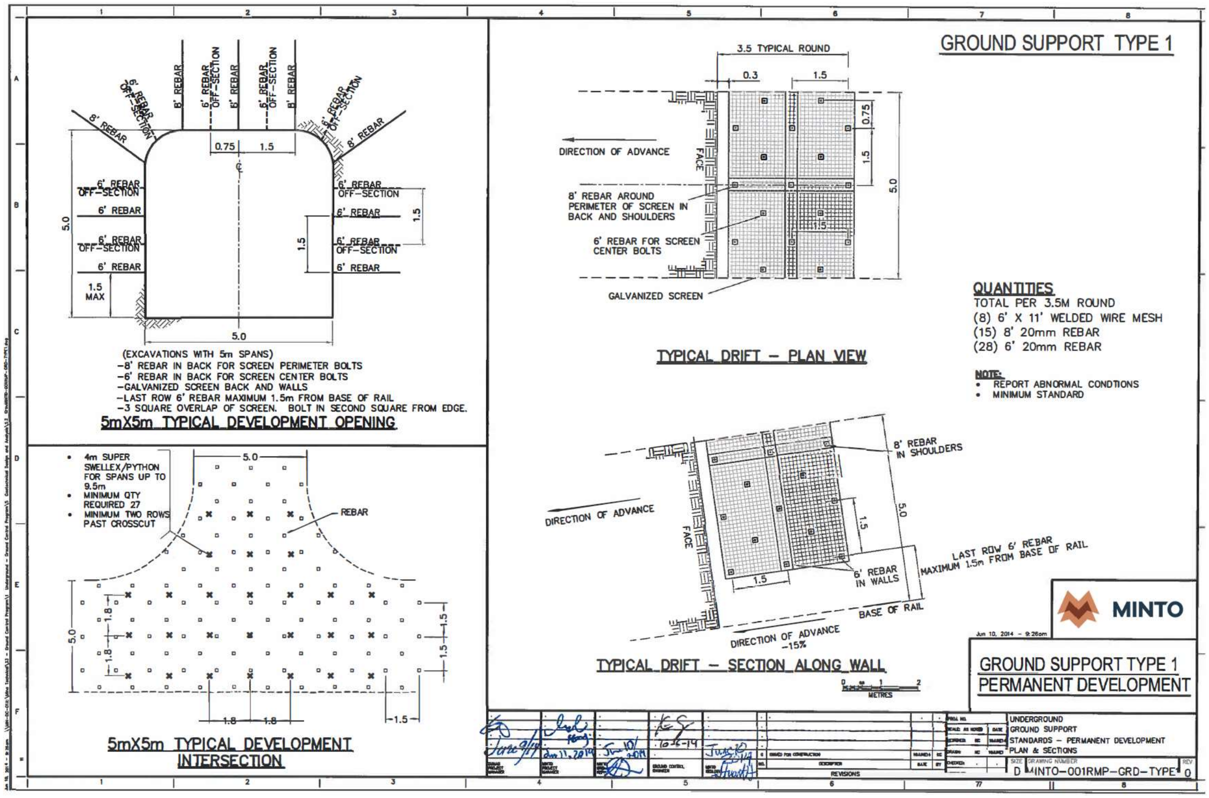
The Geotechnical Engineer is to ensure that any new legislation or developments that affect best practice in ground control are considered and where relevant incorporated into the revised GCMP. Mining legislation requires keeping track of new developments and design tools. This will involve liaison with both internal and external parties.

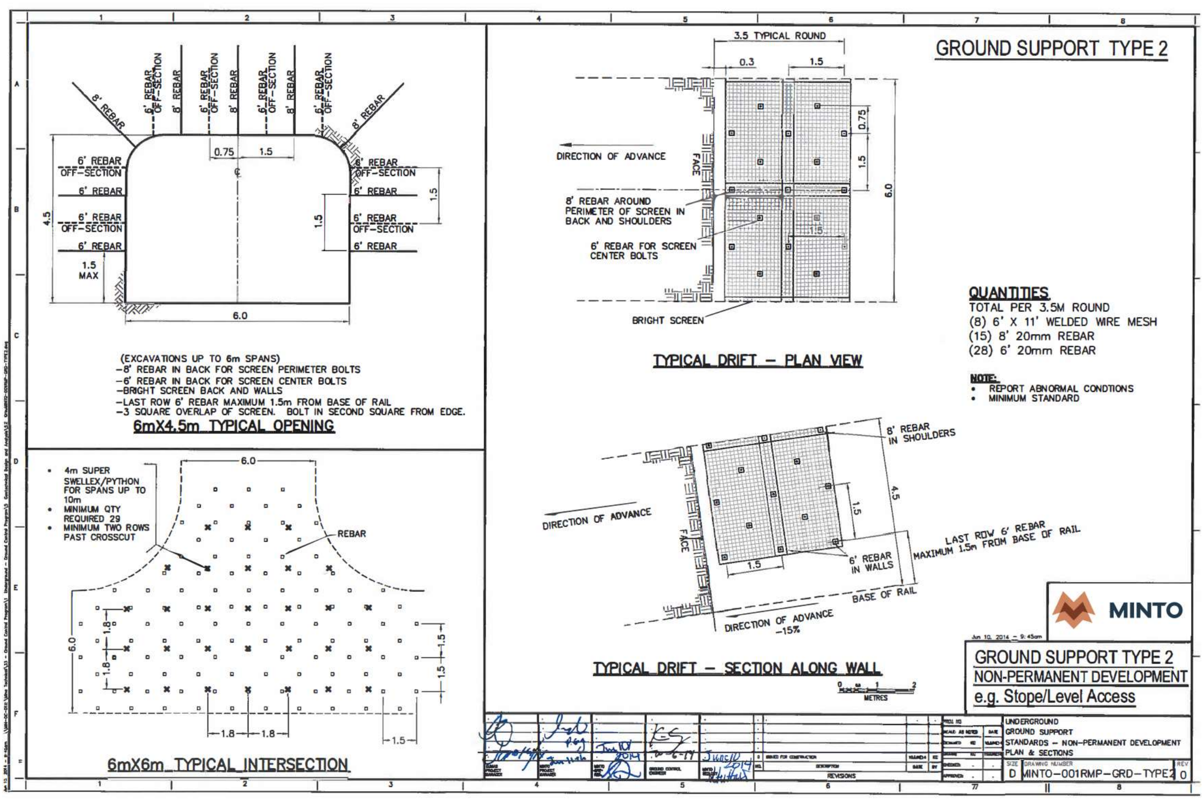
Appendix A

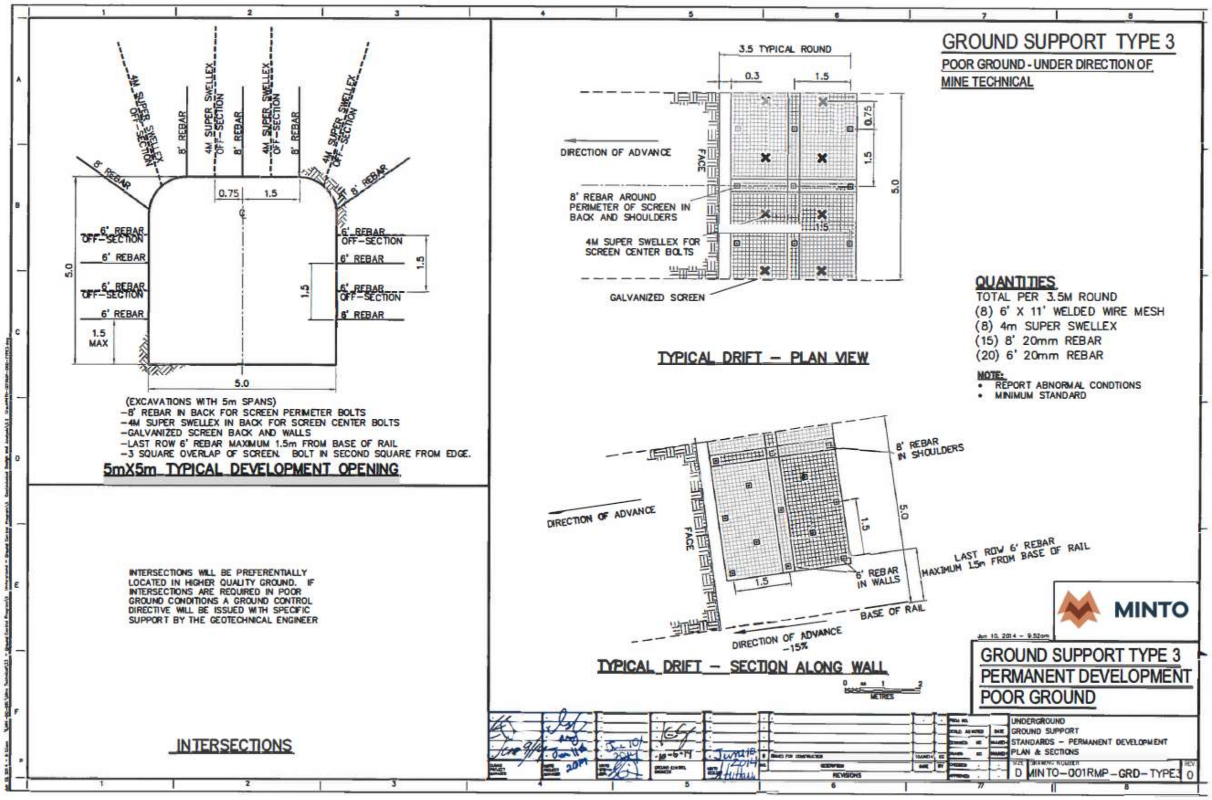
Ground Support Drawings

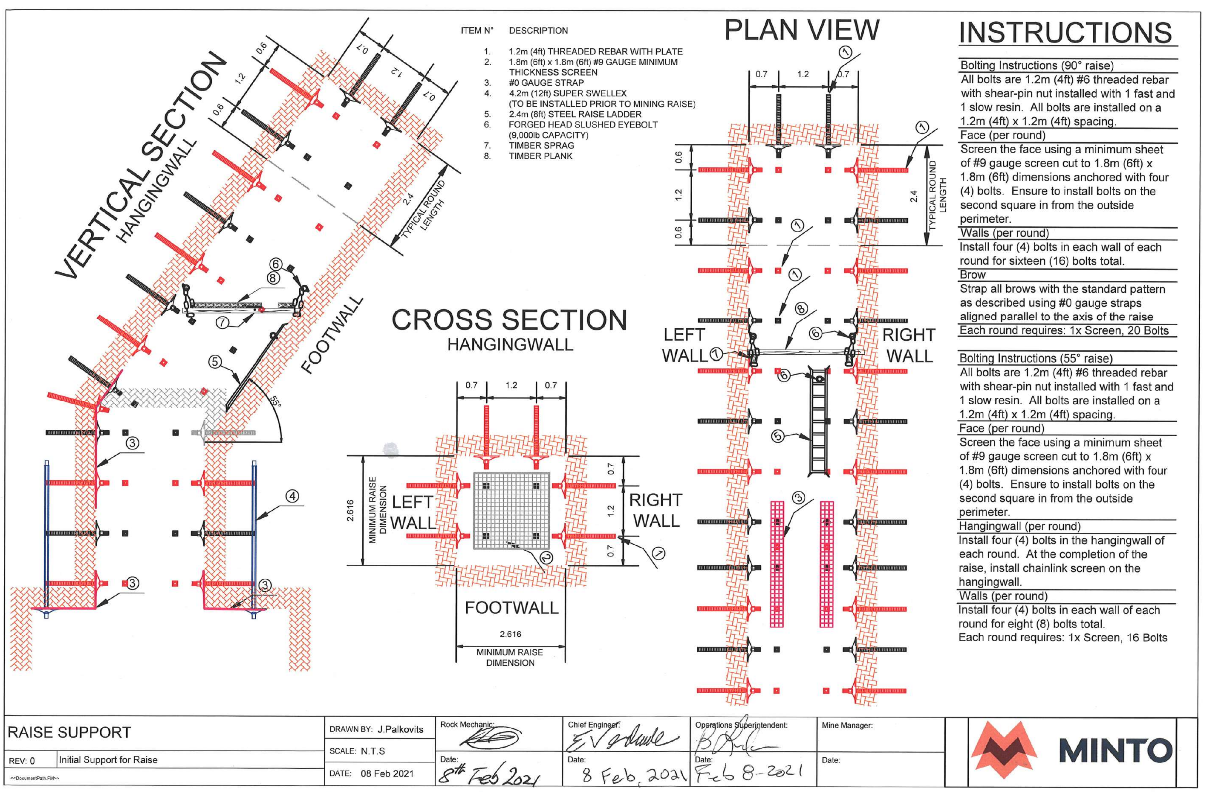

TYPE 1 WALL BOLTING PATTERN: SECTION VIEW
TYPE 1 GROUND SUPPORT STANDARD
USED IN INFRASTRUCTURE
5.5mH X 5.1mW
TYPE 1 BOLTING PATTERN: SECTION VIEW
INTERSECTION SUPPORT STANDARD
FOR SUPPORT OF SPANS OF 6.1 TO 9.5 METRES
6.1 to 9.5m
DRILL PATTERN AND LOADING
TYPE 1 BOLTING PATTERN INSTRUCTIONS
1. Overlap screen by 3 squares. Bolts may not be installed in outer edge of screen.
2. Install the bottom row of bolts to a MAXIMUM of 1.5m (5') from the floor
3. Install screen a MAXIMUM of 0.3m (1') from the face
4. 2.4m (8') Standard Swellex
5. 2.4m (8') Standard Swellex
6. 3.7m (12') Super Swellex, if required (Plan View only)
7. Bolts are to be installed on a 3-4-3 Dice 5 pattern on a 1.5m x 1.5m spacing. Dice bolts are to be offset 0.75m to the primary pattern.
8. Rabbit Ears to be installed on every second row on the shoulder bolt for services.
Intersection support is to be installed on a 1.5m x 1.5m pattern to fill in the pattern between the dice bolts.
Quantities (per 3m advance)
(8) 6' x 11' #6 wwm
(34) 2.4m (8') Standard Swellex
(3) Rabbit Ears
Intersection Quantities
3 Way: Minimum (27) 3.7m Super Swellex
4 Way: Minimum (33) 3.7m Super Swellex
Note:
Minimum standards
Report abnormal conditions
TYPE 1 BACK BOLTING PATTERN: PLAN VIEW
VENTILATION AND SERVICES
MT42
VENTILATION INSTRUCTIONS
Install 48" G+ Plastic Vent tubing to within 33m of the face. Extend 48" flexible ducting with a shot bag to within 15m of the face. Ventilation flow must physically sweep the face. Regulate flow to active faces as required when multiple branches are used.
TYPE 1 GROUND SUPPORT STANDARD
REV: 2
Added Rabbit Ears
DRAWN BY: J. Palkovits
SCALE: 1:95
DATE: 15 May 2020
Rock Mechanic:
Haydn Duffy
Date: 19 May 2020
Chief Engineer:
Date: 19 May 2020
Operations Superintendent:
Date: May 21, 2020
Mine Manager:
Date: May 30/2020
MINTO


TYPE 2 WALL BOLTING PATTERN: SECTION VIEW
TYPE 2 GROUND SUPPORT STANDARD
USED IN SILLS
4.1mH X 6mW
TYPE 2 BOLTING PATTERN: SECTION VIEW
INTERSECTION SUPPORT STANDARD
FOR SUPPORT OF SPANS OF 6.1 TO 9.5 METRES
SPAN: 6.1 to 9.5 Metres
DRILL PATTERN AND LOADING
TYPE 2 BOLTING PATTERN INSTRUCTIONS
1. Overlap screen by 3 squares. Bolts may not be installed in outer edge of screen.
2. Install the bottom row of bolts to a MAXIMUM of 1.5m (5') from the floor
3. Install screen a MAXIMUM of 0.3m (1') from the face
4. 2.4m (8') Standard Swellex
5. 2.4m (8') Standard Swellex
6. 3.7m (12') Super Swellex, if required (Plan View only)
7. Bolts are to be installed on a 3-4-3 Dice 5 pattern on a 1.5m x 1.5m spacing. Dice bolts are to be offset 0.75m to the primary pattern.
8. Rabbit Ears to be installed on every second row on the shoulder bolt for services.
Intersection support is to be installed on a 1.5m x 1.5m pattern to fill in the pattern between the dice bolts.
Intersection support is to be installed on a 1.5m x 1.5m pattern to fill in the pattern between the dice bolts.
Quantities (per 3m advance)
(8) 6' x 11' #6 wwm
(34) 2.4m (8') Standard Swellex
(3) Rabbit Ears
Intersection Quantities
3 Way: Minimum (27) 3.7m Super Swellex
4 Way: Minimum (33) 3.7m Super Swellex
Note:
Minimum standards
Report abnormal conditions
TYPE 2 BACK BOLTING PATTERN: PLAN VIEW
VENTILATION AND SERVICES
22HD
VENTILATION INSTRUCTIONS
Install 48" G+ Plastic Vent tubing to within 33m of the face. Extend 48" flexible ducting with a shot bag to within 15m of the face. Ventilation flow must physically sweep the face. Regulate flow to active faces as required when multiple branches are used.
TYPE 2 GROUND SUPPORT STANDARD
REV: 2
Moved Services to Left Wall
DRAWN BY: J. Palkovits
SCALE: 1:95
DATE: 15 May 2020
Rock Mechanic:
Haydn Duffy
Date: 19 May 2020
Chief Engineer:
Date: 19 May 2020
Operations Superintendent:
Date: May 21, 2020
Mine Manager:
Date: May 30/2020
MINTO


GROUND SUPPORT TYPE 1
3.5 TYPICAL ROUND
DIRECTION OF ADVANCE
FACE
8' REBAR AROUND PERIMETER OF SCREEN IN BACK AND SHOULDERS
6' REBAR FOR SCREEN CENTER BOLTS
GALVANIZED SCREEN
TYPICAL DRIFT – PLAN VIEW
QUANTITIES
TOTAL PER 3.5M ROUND
(8) 6' X 11' WELDED WIRE MESH
(15) 8' 20mm REBAR
(28) 6' 20mm REBAR
NOTE:
• REPORT ABNORMAL CONDITIONS
• MINIMUM STANDARD
8' REBAR IN SHOULDERS
6' REBAR IN WALLS
LAST ROW 6' REBAR MAXIMUM 1.5m FROM BASE OF RAIL
BASE OF RAIL
DIRECTION OF ADVANCE -15%
TYPICAL DRIFT – SECTION ALONG WALL
METRES
(EXCAVATIONS WITH 5m SPANS)
-8' REBAR IN BACK FOR SCREEN PERIMETER BOLTS
-6' REBAR IN BACK FOR SCREEN CENTER BOLTS
-GALVANIZED SCREEN BACK AND WALLS
-LAST ROW 6' REBAR MAXIMUM 1.5m FROM BASE OF RAIL
-3 SQUARE OVERLAP OF SCREEN. BOLT IN SECOND SQUARE FROM EDGE.
5mX5m TYPICAL DEVELOPMENT OPENING
• 4m SUPER SWELLEX/PYTHON FOR SPANS UP TO 9.5m
• MINIMUM QTY REQUIRED 27
• MINIMUM TWO ROWS PAST CROSSCUT
REBAR
5mX5m TYPICAL DEVELOPMENT INTERSECTION
MINTO
GROUND SUPPORT TYPE 1
PERMANENT DEVELOPMENT
UNDERGROUND GROUND SUPPORT STANDARDS – PERMANENT DEVELOPMENT PLAN & SECTIONS
MINTO-001RMP-GRD-TYPE1


GROUND SUPPORT TYPE 2
3.5 TYPICAL ROUND
DIRECTION OF ADVANCE
FACE
8' REBAR AROUND PERIMETER OF SCREEN IN BACK AND SHOULDERS
6' REBAR FOR SCREEN CENTER BOLTS
BRIGHT SCREEN
TYPICAL DRIFT – PLAN VIEW
QUANTITIES
TOTAL PER 3.5M ROUND
(8) 6' X 11' WELDED WIRE MESH
(15) 8' 20mm REBAR
(28) 6' 20mm REBAR
NOTE:
• REPORT ABNORMAL CONDITIONS
• MINIMUM STANDARD
8' REBAR IN SHOULDERS
6' REBAR IN WALLS
LAST ROW 6' REBAR MAXIMUM 1.5m FROM BASE OF RAIL
BASE OF RAIL
DIRECTION OF ADVANCE -15%
TYPICAL DRIFT – SECTION ALONG WALL
METRES
(EXCAVATIONS UP TO 6m SPANS)
-8' REBAR IN BACK FOR SCREEN PERIMETER BOLTS
-6' REBAR IN BACK FOR SCREEN CENTER BOLTS
-BRIGHT SCREEN BACK AND WALLS
-LAST ROW 6' REBAR MAXIMUM 1.5m FROM BASE OF RAIL
-3 SQUARE OVERLAP OF SCREEN. BOLT IN SECOND SQUARE FROM EDGE.
6mX4.5m TYPICAL OPENING
• 4m SUPER SWELLEX/PYTHON FOR SPANS UP TO 10m
• MINIMUM QTY REQUIRED 29
• MINIMUM TWO ROWS PAST CROSSCUT
REBAR
6mX6m TYPICAL INTERSECTION
MINTO
GROUND SUPPORT TYPE 2
NON-PERMANENT DEVELOPMENT
e.g. Stope/Level Access
UNDERGROUND GROUND SUPPORT STANDARDS – NON-PERMANENT DEVELOPMENT PLAN & SECTIONS
MINTO-001RMP-GRD-TYPE2


GROUND SUPPORT TYPE 3
POOR GROUND - UNDER DIRECTION OF MINE TECHNICAL
5mX5m TYPICAL DEVELOPMENT OPENING
(EXCAVATIONS WITH 5m SPANS)
-8' REBAR IN BACK FOR SCREEN PERIMETER BOLTS
-4M SUPER SWELLEX IN BACK FOR SCREEN CENTER BOLTS
-GALVANIZED SCREEN BACK AND WALLS
-LAST ROW 6' REBAR MAXIMUM 1.5m FROM BASE OF RAIL
-3 SQUARE OVERLAP OF SCREEN. BOLT IN SECOND SQUARE FROM EDGE.
TYPICAL DRIFT – PLAN VIEW
DIRECTION OF ADVANCE
8' REBAR AROUND PERIMETER OF SCREEN IN BACK AND SHOULDERS
4M SUPER SWELLEX FOR SCREEN CENTER BOLTS
GALVANIZED SCREEN
QUANTITIES
TOTAL PER 3.5M ROUND
(8) 6' X 11' WELDED WIRE MESH
(8) 4m SUPER SWELLEX
(15) 8' 20mm REBAR
(20) 6' 20mm REBAR
NOTE:
• REPORT ABNORMAL CONDITIONS
• MINIMUM STANDARD
TYPICAL DRIFT – SECTION ALONG WALL
8' REBAR IN SHOULDERS
6' REBAR IN WALLS
LAST ROW 6' REBAR MAXIMUM 1.5m FROM BASE OF RAIL
BASE OF RAIL
DIRECTION OF ADVANCE -15%
INTERSECTIONS WILL BE PREFERENTIALLY LOCATED IN HIGHER QUALITY GROUND. IF INTERSECTIONS ARE REQUIRED IN POOR GROUND CONDITIONS A GROUND CONTROL DIRECTIVE WILL BE ISSUED WITH SPECIFIC SUPPORT BY THE GEOTECHNICAL ENGINEER
INTERSECTIONS
MINTO
GROUND SUPPORT TYPE 3
PERMANENT DEVELOPMENT
POOR GROUND
UNDERGROUND GROUND SUPPORT STANDARDS – PERMANENT DEVELOPMENT PLAN & SECTIONS
D MINTO-001RMP-GRD-TYPE3 0


VERTICAL SECTION
HANGINGWALL
FOOTWALL
ITEM N° DESCRIPTION
1. 1.2m (4ft) THREADED REBAR WITH PLATE
2. 1.8m (6ft) x 1.8m (6ft) #9 GAUGE MINIMUM THICKNESS SCREEN
3. #0 GAUGE STRAP
4. 4.2m (12ft) SUPER SWELLEX (TO BE INSTALLED PRIOR TO MINING RAISE)
5. 2.4m (8ft) STEEL RAISE LADDER
6. FORGED HEAD SLUSHED EYEBOLT (9,000lb CAPACITY)
7. TIMBER SPRAG
8. TIMBER PLANK
CROSS SECTION
HANGINGWALL
LEFT WALL
RIGHT WALL
FOOTWALL
MINIMUM RAISE DIMENSION
PLAN VIEW
TYPICAL ROUND LENGTH
INSTRUCTIONS
Bolting Instructions (90° raise)
All bolts are 1.2m (4ft) #6 threaded rebar with shear-pin nut installed with 1 fast and 1 slow resin. All bolts are installed on a 1.2m (4ft) x 1.2m (4ft) spacing.
Face (per round)
Screen the face using a minimum sheet of #9 gauge screen cut to 1.8m (6ft) x 1.8m (6ft) dimensions anchored with four (4) bolts. Ensure to install bolts on the second square in from the outside perimeter.
Walls (per round)
Install four (4) bolts in each wall of each round for sixteen (16) bolts total.
Brow
Strap all brows with the standard pattern as described using #0 gauge straps aligned parallel to the axis of the raise
Each round requires: 1x Screen, 20 Bolts
Bolting Instructions (55° raise)
All bolts are 1.2m (4ft) #6 threaded rebar with shear-pin nut installed with 1 fast and 1 slow resin. All bolts are installed on a 1.2m (4ft) x 1.2m (4ft) spacing.
Face (per round)
Screen the face using a minimum sheet of #9 gauge screen cut to 1.8m (6ft) x 1.8m (6ft) dimensions anchored with four (4) bolts. Ensure to install bolts on the second square in from the outside perimeter.
Hangingwall (per round)
Install four (4) bolts in the hangingwall of each round. At the completion of the raise, install chainlink screen on the hangingwall.
Walls (per round)
Install four (4) bolts in each wall of each round for eight (8) bolts total.
Each round requires: 1x Screen, 16 Bolts
RAISE SUPPORT
REV: 0 Initial Support for Raise
DRAWN BY: J.Palkovits
SCALE: N.T.S
DATE: 08 Feb 2021
Rock Mechanic:
Chief Engineer:
Operations Superintendent:
Mine Manager:
8th Feb 2021
8 Feb, 2021
Feb 8-2021
MINTO

Appendix B

Kinematic Analysis

Kinematic Analysis of Omega 12T bolts as primary support

At Minto Mine

Introduction

A kinematic analysis was completed for the Copper Keel area underground, using the Rocscience software Unwedge.

14 Joint sets were identified and mapped, shown on the following two tables (Figures 12 & 13):

Joint sets were analysed and the 3 joint sets producing the lowest factor of safety were 3,12 and 13.

A further kinematic assessment was carried out in February 2021 to calibrate initial assessments. The joint sets observed remained the same thus calibrating the initial assessment as still valid.

Figure 12 Mapped Joints Copper Keel

Joint Orientations

Joint	Dip	Dip Direction	Properties
1	65	149	Waste
2	85	181	Waste
3	40	137	Waste
4	85	240	Waste
5	75	114	Waste
6	80	231	Waste
7	80	133	Waste

Figure 13 Mapped Joints Copper Keel

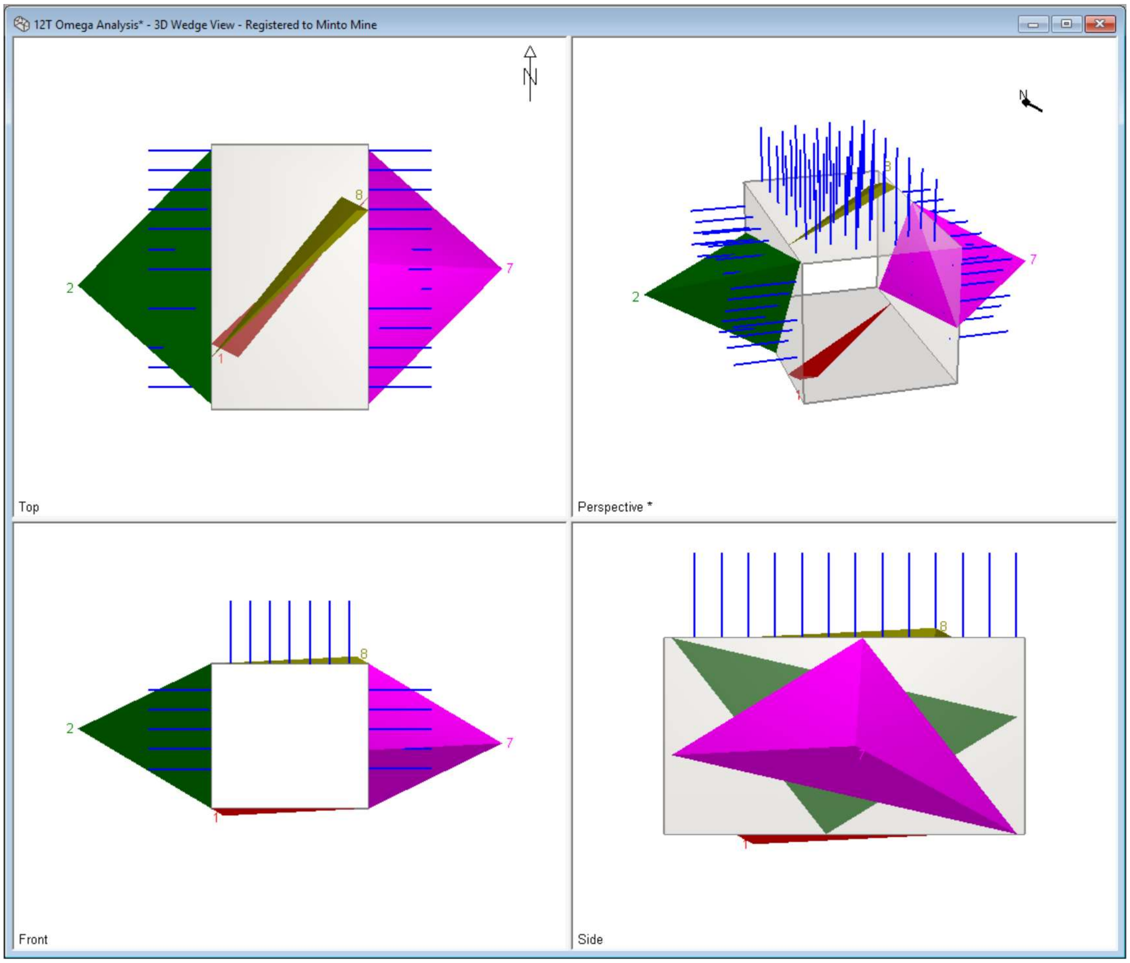
Joint Orientations

Joint	Dip	Dip Direction	Properties
8	85	195	Waste
9	65	152	Waste
10	60	337	Waste
11	45	191	Waste
12	55	27	Waste
13	20	309	Waste
14	55	31	Waste

The drift orientation giving the lowest FOS was N/S although the identified wedge in the back was small with a potential weight of 1.17 tonnes. This is within #6 screen bagged load capacity of 2-3 tonnes per square meter so is not considered significant.

Drift orientations of 45, 90 and 135 degrees were also analysed to check FOS against possible adverse drift orientation. The results are shown on figures 3 to 7.

Figure 14 Drift Orientation N/S



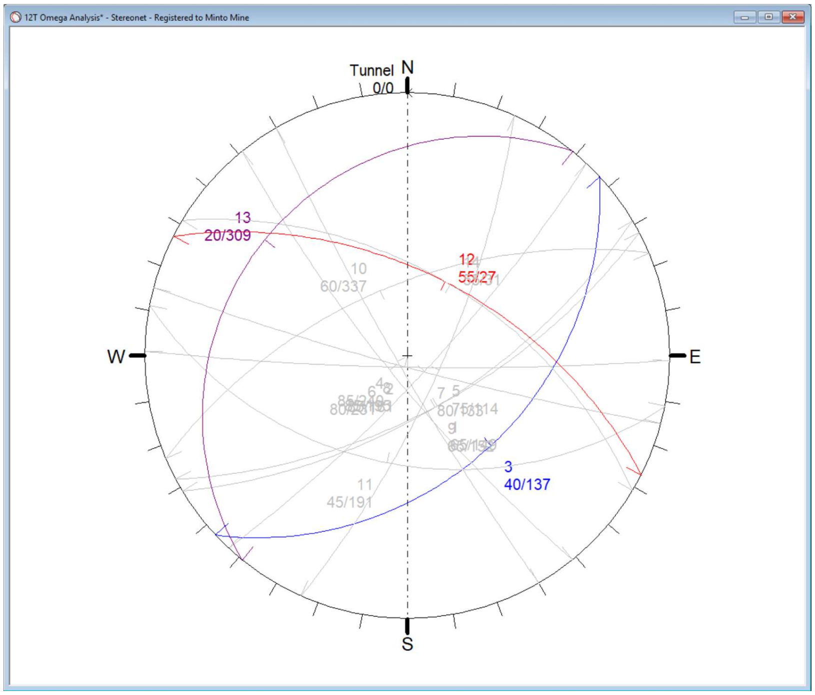

12T Omega Analysis* - Stereonet - Registered to Minto Mine
Tunnel
0/0
N
S
W
E
13
20/309
12
55/27
10
60/337
3
40/137
11
45/191

Figure 15 Drift Orientation NE/SW

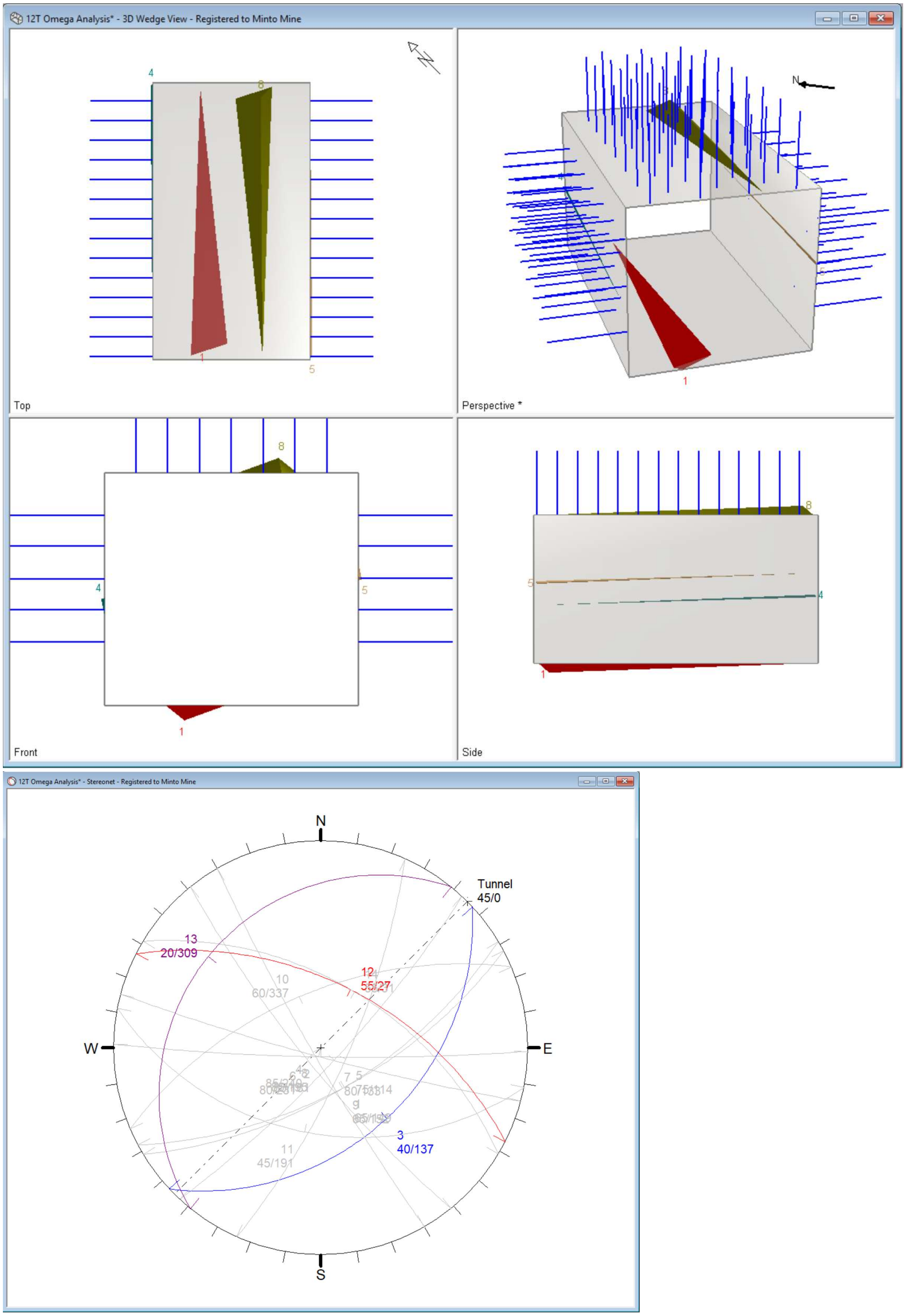


Figure 16 Drift Orientation E/W

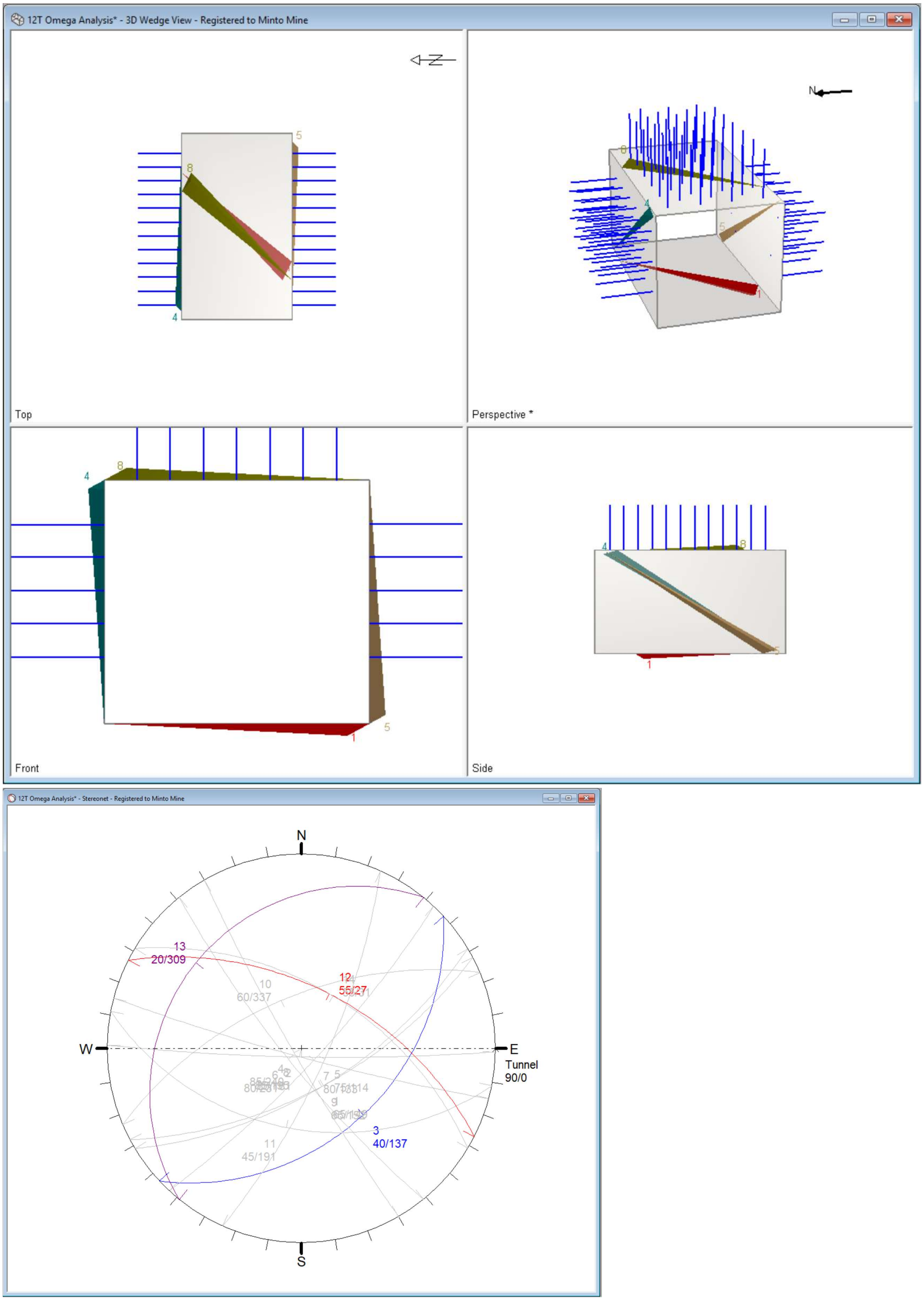


Figure 17 Drift Orientation NW/SE

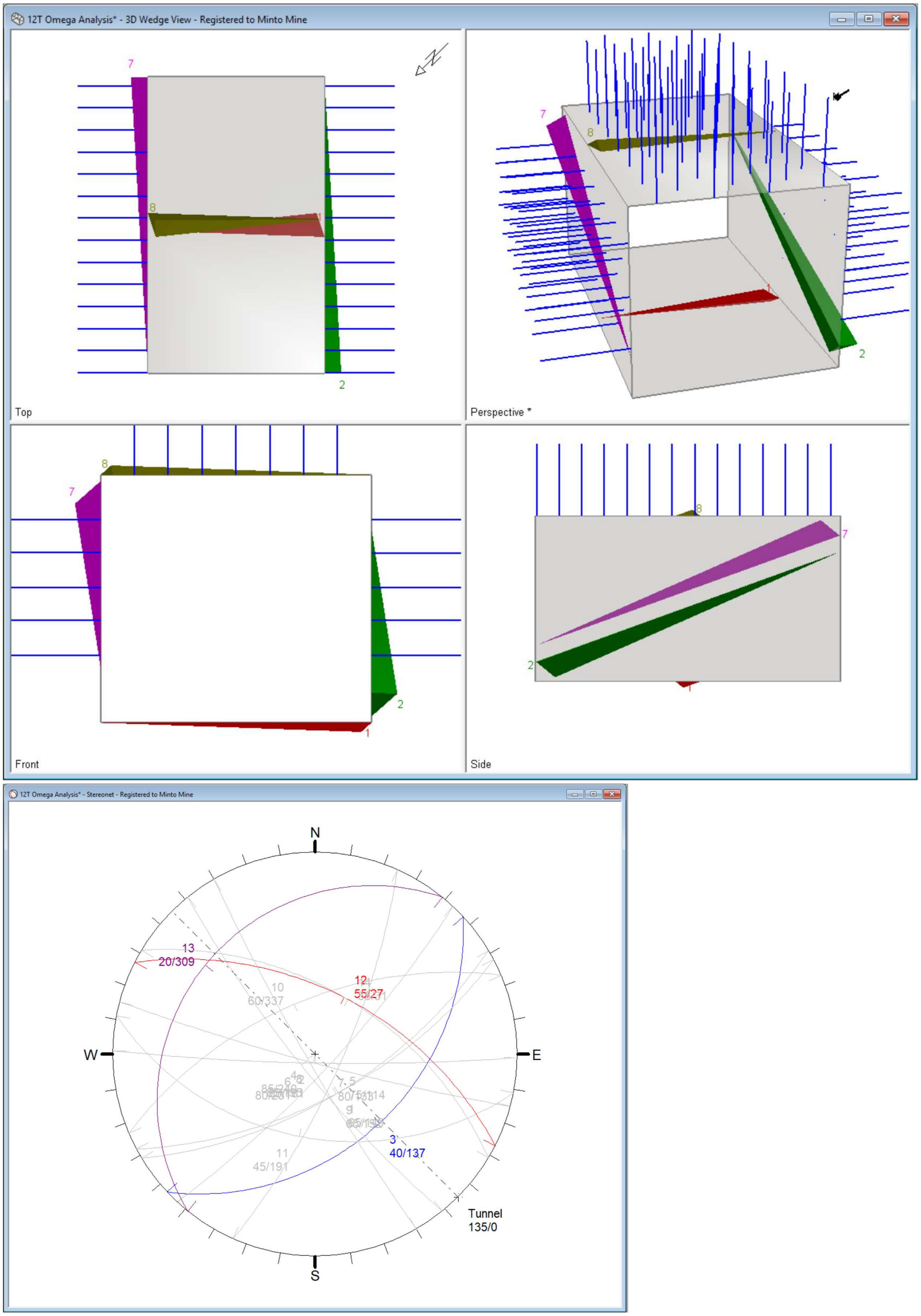
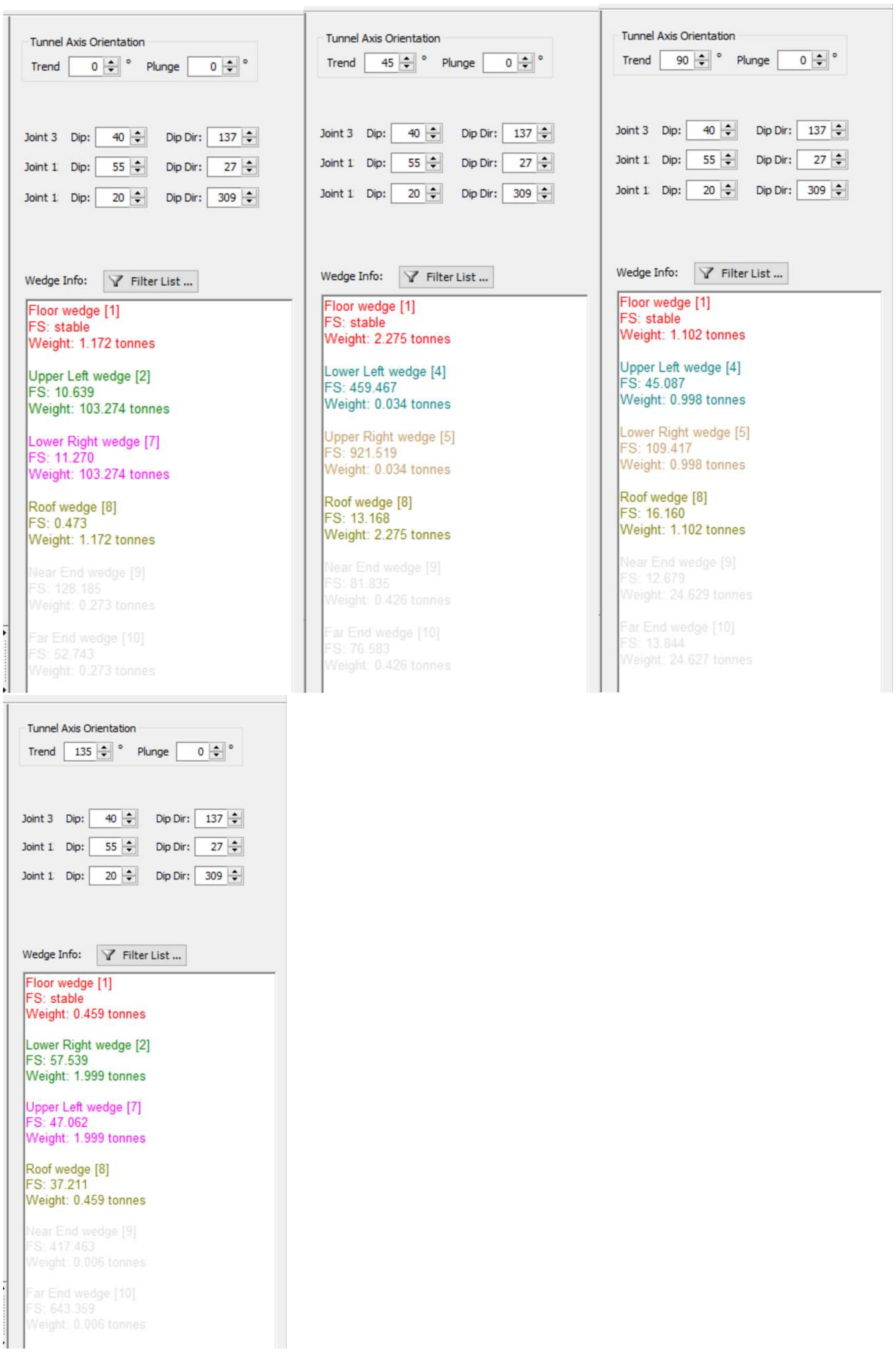


Figure 18 Data Tables of Drift Orientation



Appendix C

File Locations

Documents	File Locations
Reports	X:\Mine Technical\33 - Ground Control Program\1 Underground - Ground Control Program\6 Reports
Ground Control Directives	X:\Mine Technical\33 - Ground Control Program\1 Underground - Ground Control Program\2 Design and Analysis\1 Ground Support\Ground Control Directives
Ground Falls	X:\Mine Technical\33 - Ground Control Program\1 Underground - Ground Control Program\4 Groundfalls and Rehabilitation\Ground Falls
Ground Support Analysis	X:\Mine Technical\33 - Ground Control Program\1 Underground - Ground Control Program\2 Design and Analysis\1 Ground Support\Ground Support Analysis
Ground Support Standards	X:\Mine Technical\33 - Ground Control Program\1 Underground - Ground Control Program\2 Design and Analysis\1 Ground Support\Ground Support Standards\Current\Signed
Inspections	X:\Mine Technical\33 - Ground Control Program\1 Underground - Ground Control Program\3 Monitoring, Inspections and Instrumentation\Inspections
Annual Inspections	X:\Mine Technical\23 - Annual Inspection Reports for EMR
Mapping and Core Logging	X:\Mine Technical\33 - Ground Control Program\1 Underground - Ground Control Program\1 Mapping and Logging
Rehabilitation logbook	X:\Mine Technical\33 - Ground Control Program\1 Underground - Ground Control Program\4 Groundfalls and Rehabilitation\Rehabilitation
Pull Testing	X:\Mine Technical\33 - Ground Control Program\1 Underground - Ground Control Program\3 Monitoring, Inspections and Instrumentation\Pull Testing
Bolter QA/QC	X:\Mine Technical\33 - Ground Control Program\1 Underground - Ground Control Program\3 Monitoring, Inspections and Instrumentation\Bolter QA-QC
Kinematic Analysis	X:\Mine Technical\33 - Ground Control Program\1 Underground - Ground Control Program\2 Design and Analysis\1 Ground Support\Ground Support Analysis\Current
WROMP	X:\Mine Technical\17 – Water Management\ 19 - Waste Dumps\8. WROMP