November 23, 2022 GeoServ, Inc. Job No. 210126

Attention: Jim Hayes

Subject: Waddell Rock Quarry Slope Stability Analysis Report

Dear Jim,

In accordance with your request and authorization of GeoServ, Inc. has completed a slope stability at Waddell Rock Quarry. The attached report contains the results of our site investigation and engineering geologic evaluation of the slope stability elements of the project site.

Based on GeoServ Inc's subsurface investigations and our geotechnical and engineering evaluation, the project is considered feasible from a geotechnical standpoint provided the recommendations contained in the attached report are incorporated into the project design and construction. If you have any questions regarding our findings or recommendations, please do not hesitate to contact this office. The opportunity to be of service is appreciated.

Respectfully submitted,

James Fitzgerald, CEG (2436)
GeoServ, Inc.

Waddell Rock Quarry Slope Stability Analysis Report

Prepared for: Jim Hayes

Prepared by: GeoServ, Inc. (GSI)

Revision A review draft date: 11/23/2022

Table of Contents

Introduction

This slope stability report documents the Waddell Rock Quarry slope stability analysis methods, data results, and slope stability analysis results. This analysis mapped and drafted lithotopo units using the site investigation data, anecdotal information, and historical photographs. The slope stability analysis results were used to evaluate the proposed slope geometry during and after mining operations. Professional judgement and model results were used to estimate and interpolate subsurface material types. To represent the different types of the rock slope, 2-D sections were cut and used to model slope stability for the proposed conditions conditions (Sheets 1 to 4 and Attachment A).

Methods

Site Investigation Data Collection Methods

A site investigation was completed to obtain information on the engineering properties of the rock, soil, groundwater, and to inform the designs and construction techniques for the rock quarry. The engineering properties of the project area rocks and soils were assessed using industry standard methods (e.g., CDC 2001, Williamson 1984, and BOR 2001). The rocks and soils were classified and assessed following the most recent ASTM methods.

The site investigation was completed in September 2022. The bedrock mapping sites were located along the proposed quarry expansion area in safe accessible locations to characterize the spatial distribution of the terrane, rock, soil, and water conditions. This investigation process was intended to assess the spatial and temporal distribution of soil or rock near the ground surface.

The bedrock mapping occurred along the bedrock outcrops that are within the proposed quarry expansion area and were completed by GSI geologists. The accessible outcrops were classified using ASTM. Rock samples were collected for Specific Gravity and Point Load Testing to help characterize the rock density and strength.

Slope Stability Model Methods

Slope stability model parameters were measured, calculated, or estimated using the available field data following standard methods. Slide 6.0 was used to model the temporary and permanent stability of the quarry face during mining. The 2-D slope stability analysis software is comprehensive for the level of design effort and performs finite element analysis. The quarry design was analyzed based on the proposed earthworks and the geometry of cut-slopes. The following methods were used to model slope stability:

Slide 2D limit equilibrium slope stability model to complete non-circular and circular failure analyses on existing and design rock cut and fill slopes to help define critical rock slope failure mechanisms and planes (Rocscience, Inc. 2002).

- Spencer (Blake et. al. 2002), Army Corp #1, and Army Corp#2 methods to predict non-circular and circular critical failure planes and fill slope FOS.
- Plane Failure method to analyze rock slope stability (Hoek and Bray 1981).

The following criteria were used for the temporary and permanent slope stability analyses.

- Static Factor of Safety (FOS) for temporary rock cut-slopes = 1.5.

The model assumes uniform rock and soil engineering properties for the dominant rock type to include:

- Paleozoic marine, undivided (Pz)

The model assumes that the modern cut-slopes and fill-slopes are pseudo-stable (i.e., FOS = 1.0) along the existing quarry face. It also assumes that the rock slopes are presently in a pseudo-stable condition (i.e., FOS = 1.0) other than shallow rock fall (i.e., <5' into slope face).

The rock slope models factored freeze-thaw failure mechanisms by assuming conservative fracture/joint discontinuity cohesion and angle of internal friction values (Table 1). It also assumed a value 33% for pore pressure for planar and rock topple failure models and that the groundwater level is lower than ground surface and fractures/joints in the rock are free draining.

Site Investigation Results

Bedrock Mapping

Accessible rock outcrops were mapped as part of the site investigation (Sheet 1). The results of the bedrock mapping are consistent with the Paleozoic marine, undivided (Pz) reported in the available geologic maps.

Slope Stability

Based upon GSI's review of the published geologic maps, aerial photographs, ground topography data, site reconnaissance, and slope stability modeling, the project area appears to be quasi stable under static conditions. The project area topography is steep due to shallow and hard Paleozoic marine rock. No evidence of active or dormant landslide slip plain surfaces were observed as part of the site investigation and no springs or seeps were observed.

Slope stability modeling results indicate that the existing slopes have a FOS of 1 for static conditions. The design slopes have a FS greater than 1.5 under static conditions Attachment A). The site investigation results were used to estimate and interpolate subsurface material types. To represent the different types of slopes within the project area, 2-D sections were cut and used to model slope stability for existing and design conditions (Sheets 1 to 4 and Attachment A).

Modeling results for static rock slope stability conditions indicate that the proposed quarry geometry are stable with FS greater than the design criteria (Attachment A). Rock slope failure sensitivity analysis indicates that percent fill pore pressure, slope angle, and slope height and the top three limiting factors.

References

Blake, T.F., Hollingsworth, R.A., and Stewart, J.P., eds (2002), Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Landslide Hazards in California, Organized through the American Society of Civil Engineers, Los Angeles Section (ASCE-LA) – SCEC), 110 pp.

California Department of Conservation (CDC), 1999. Factors Affecting Landslides in Forested Terrain. California Division of Mines and Geology, Note 50.

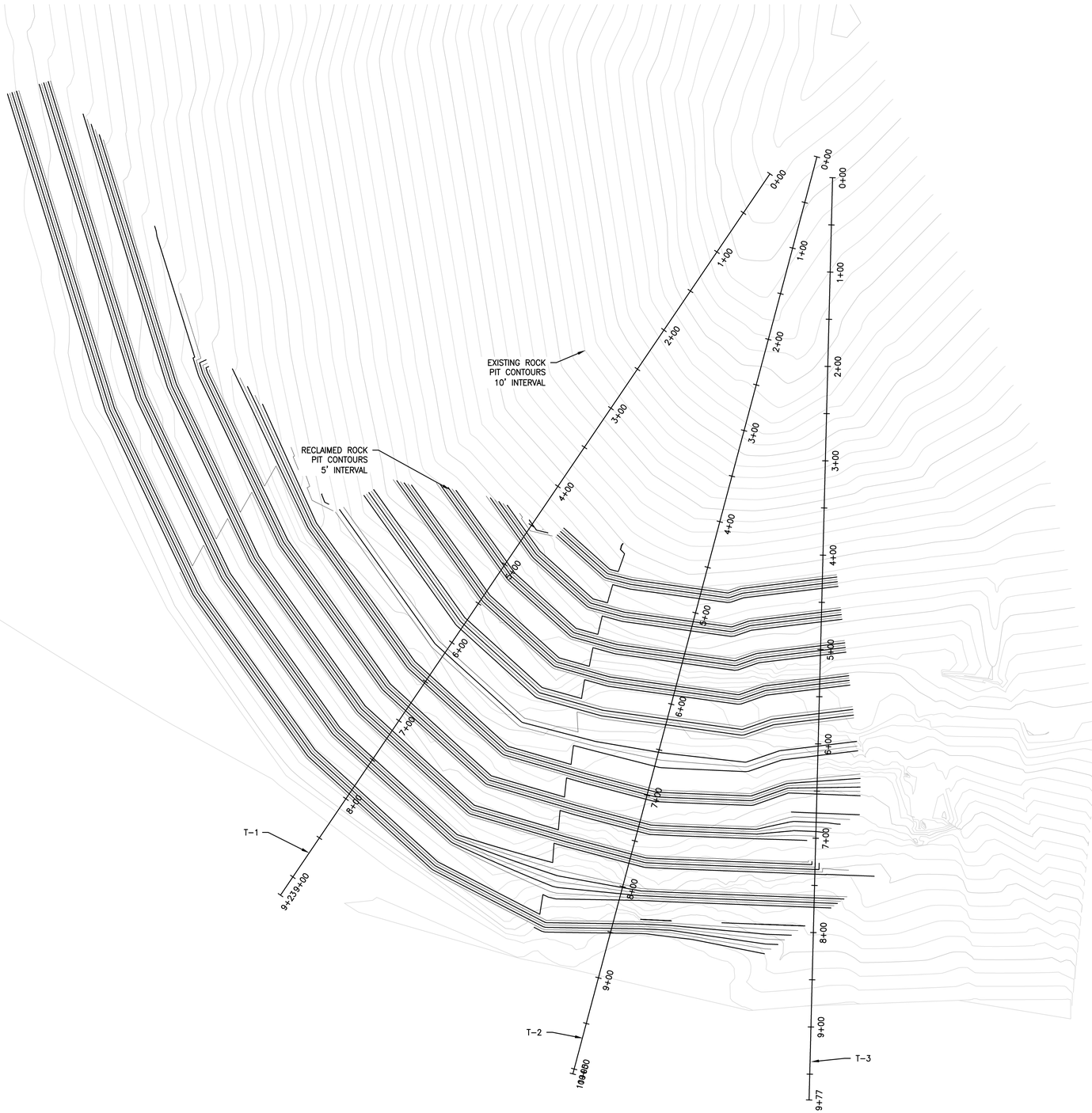
Cruden, D.M., and Varnes, D.J., 1996. Landslide types and processes. Pages 36-75 in A.K. Turner and R.L. Schuster, editors. Landslides Investigation and Mitigation. National Research Council Transportation Research Board Special Report 247, National Academy Press, Washington, DC.

Hoek and Bray, 1981. Rock Slope Engineering, 3rd edition, Chapman & Hall, London.

Rocscience, Inc., 2002. Slide 2D limit equilibrium slope stability for soil and rock slopes, User's Guide.

United States Army Corps of Engineers (ACOE), 2003. Engineering and Design: Slope Stability. Manual No. 1110-2-1902.

United States Bureau of Reclamation (BOR), 2001. Engineering Geology Field Manual, Second Edition, Volume I.



GEOSERV, INC.

2731 FRYERS WAY
MOUNT SHASTA, CA 96067
PH: (530) 227-8963
FAX: (530) 926-8921

WADDELL ROCK PIT SLOPE STABILITY ANALYSIS

INDIAN CREEK RD, SISKIYOU COUNTY, CA

FOR REVIEW

SHEET NAME:
GRADING SLOPE STABILITY PLAN

REVISIONS:

PROJECT NO:

ISSUE DATE: 11/23/2022

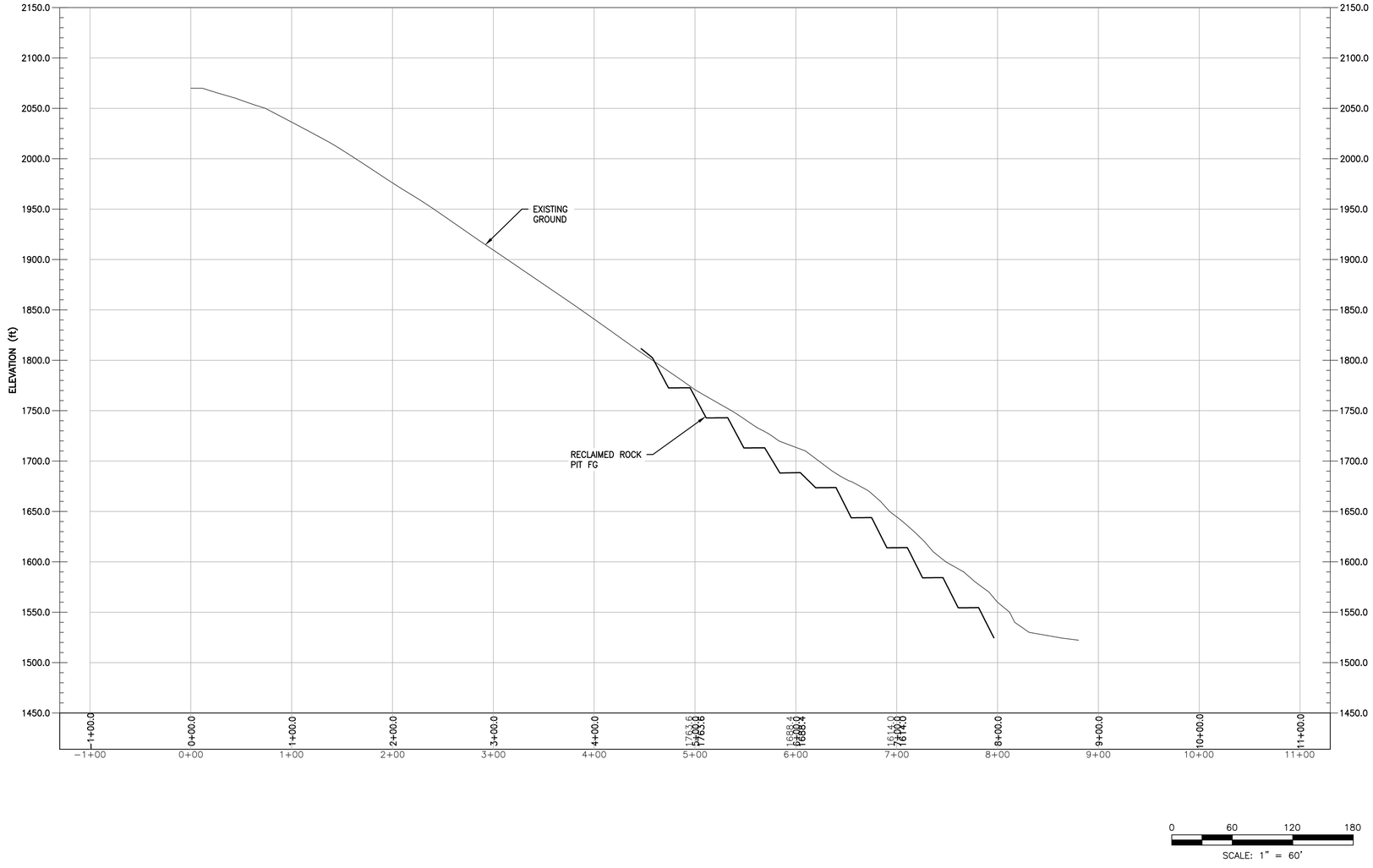
SCALE: AS NOTED

DRAWN BY: KJF

ENGINEERED: JKF

CHECKED: JKF

FIGURE: **1**



0 60 120 180

SCALE: 1" = 60'

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MOUNT SHASTA, CA 96067
PH: (530) 227–8963
FAX: (530) 926–8921

WADDELL ROCK PIT SLOPE STABILITY ANALYSIS

INDIAN CREEK RD, SISKIYOU COUNTY, CA

FOR REVIEW

SHEET NAME:

GRADING
SLOPE STABILITY
SECTION T–1

REVISIONS:

PROJECT NO:

ISSUE DATE:
11/23/2022

SCALE:
AS NOTED

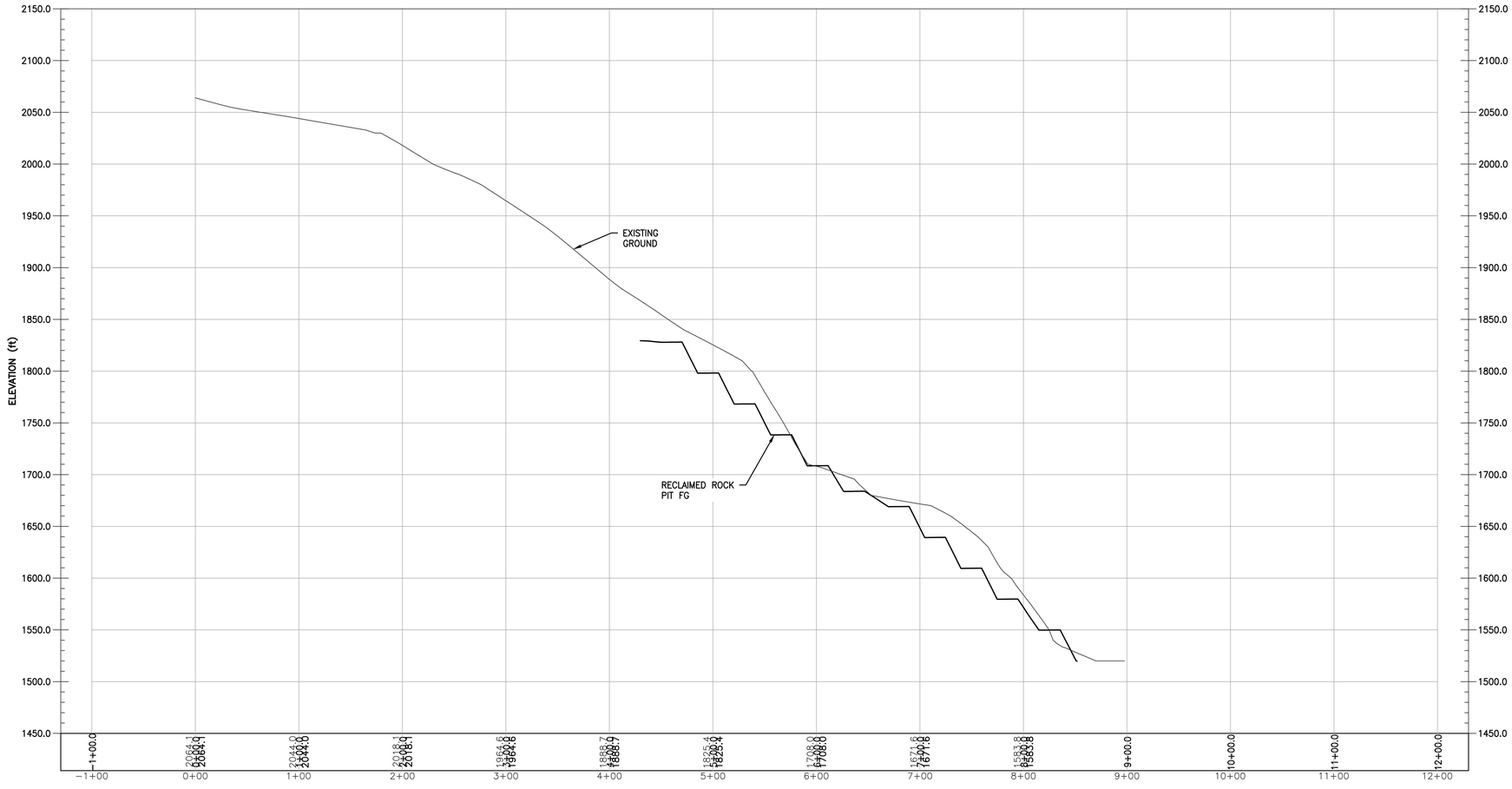
DRAWN BY:
KJF

ENGINEERED:
JKF

CHECKED:
JKF

FIGURE:

2



0 60 120 180

SCALE: 1" = 60'

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2731 FRYERS WAY
MOUNT SHASTA, CA 96067
PH: (530) 227–8963
FAX: (530) 926–8921

WADDELL ROCK PIT SLOPE STABILITY ANALYSIS

INDIAN CREEK RD, SISKIYOU COUNTY, CA

FOR REVIEW

SHEET NAME:

GRADING
SLOPE STABILITY
SECTION T–2

REVISIONS:

PROJECT NO:

ISSUE DATE: 11/23/2022

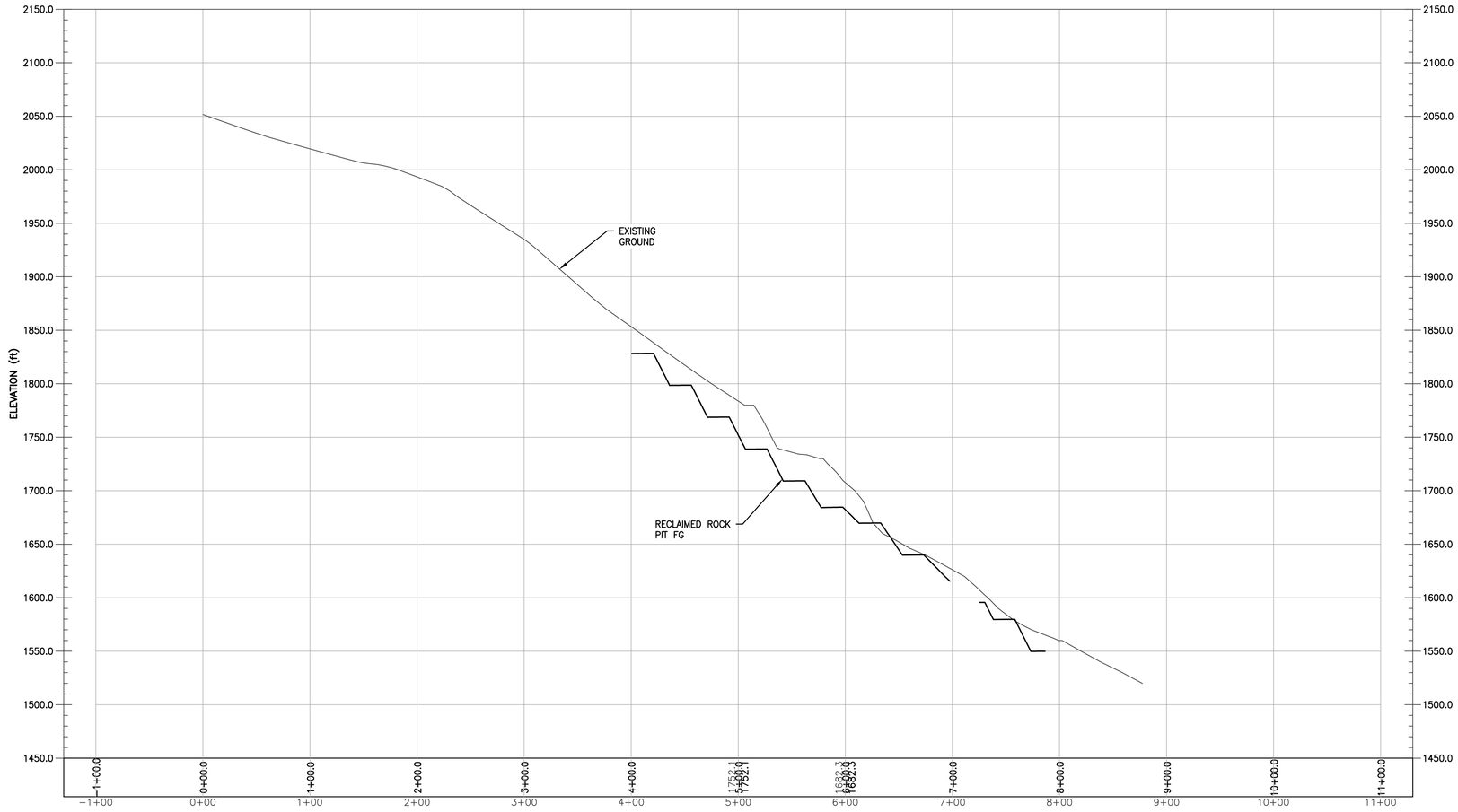
SCALE: AS NOTED

DRAWN BY: KJF

ENGINEERED: JKF

CHECKED: JKF

FIGURE: **3**



0 60 120 180

SCALE: 1" = 60'

GEOSERV, INC.

2731 FRYERS WAY
MOUNT SHASTA, CA 96067
PH: (530) 227-8963
FAX: (530) 926-8921

WADDELL ROCK PIT SLOPE STABILITY ANALYSIS

INDIAN CREEK RD, SISKIYOU COUNTY, CA

FOR REVIEW

SHEET NAME:

GRADING SLOPE STABILITY SECTION T-3

REVISIONS:

PROJECT NO:

ISSUE DATE: 11/23/2022

SCALE: AS NOTED

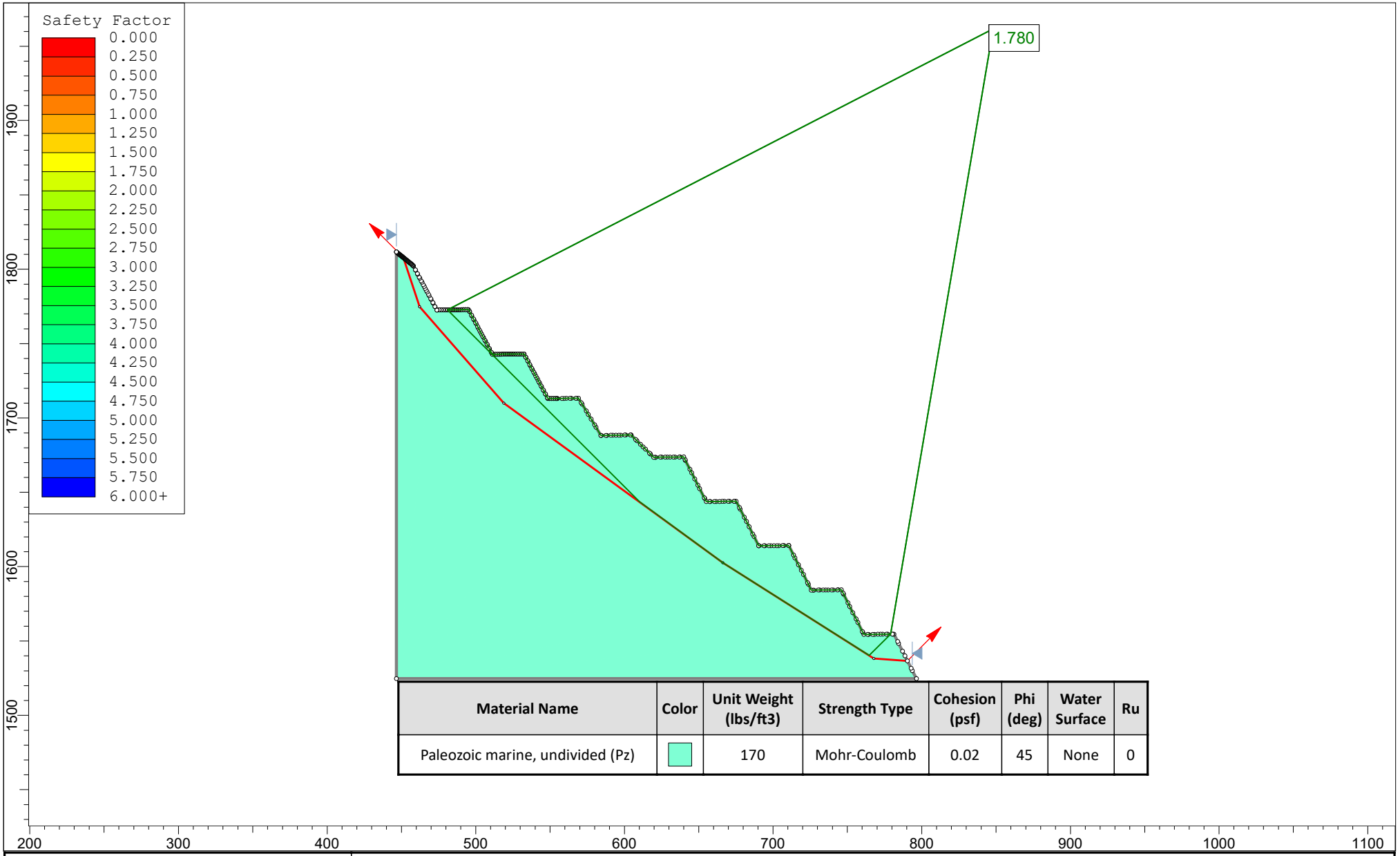
DRAWN BY: KJF

ENGINEERED: JKF

CHECKED: JKF

FIGURE: **4**

Attachment A



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Paleozoic marine, undivided (Pz)		170	Mohr-Coulomb	0.02	45	None	0

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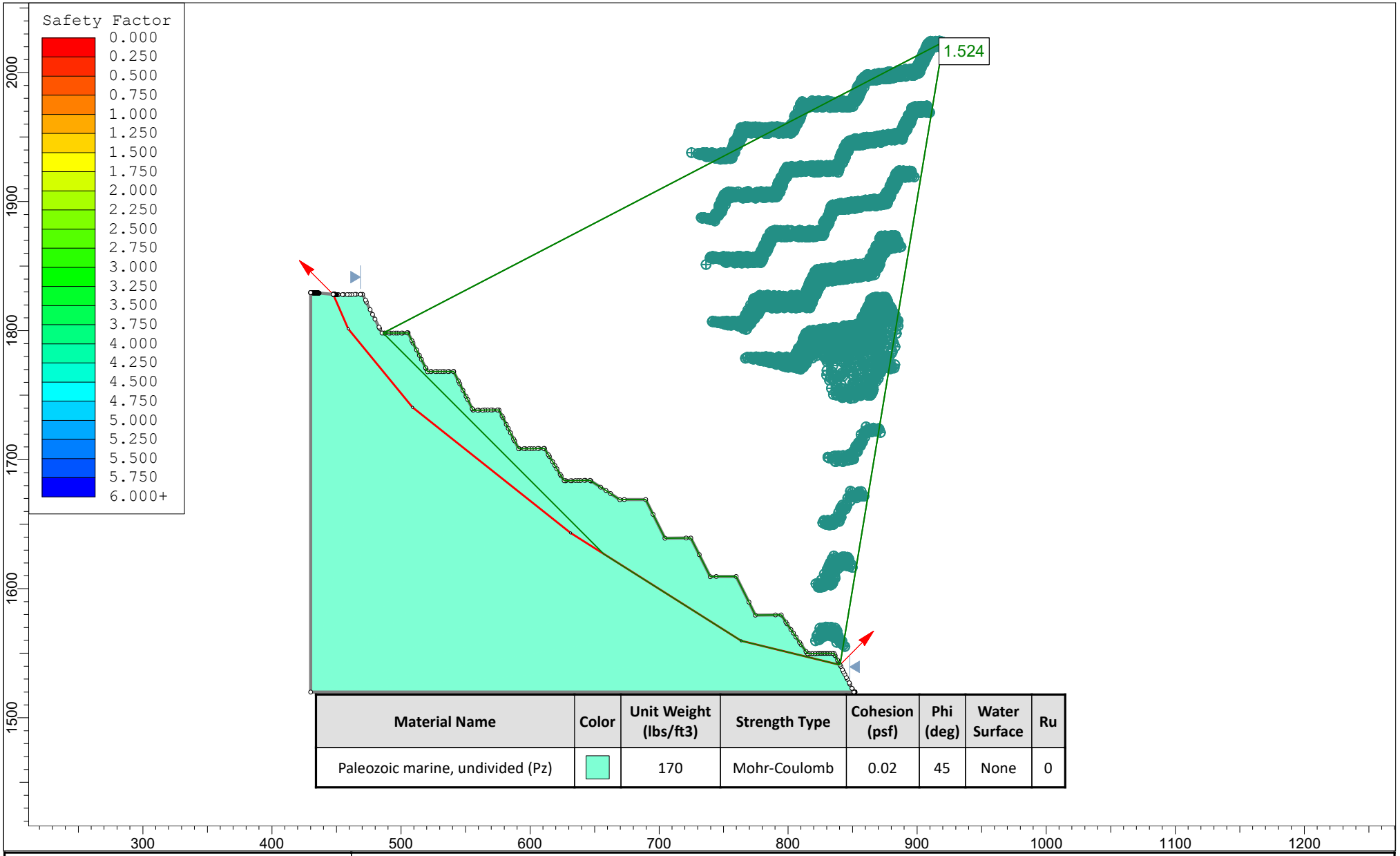
SLIDEINTERPRET 6.039

Project	Waddell Rock Quarry T-1		
Analysis Description	Rock Block Analysis		
Drawn By	James Fitzgerald	*Company*	GSI
Date	11/20/2022	*File Name*	Waddell_Rx_Pit_Rx_Slope_Stab_T1.slim

********** Summary **********

Slope Height = 287
Slope Face Angle = 38
Upper Slope Angle = 25
Cohesion = 0
Friction Angle = 40
Discontinuity Angle = 27
Unit Weight of Rock = 175
Unit Weight of Water = 64
Crest Location = 367.34
Discontinuity Length = 3004.75
Weight of Rock Block = 23385981.6

Stability Factor = 1.647



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Paleozoic marine, undivided (Pz)		170	Mohr-Coulomb	0.02	45	None	0

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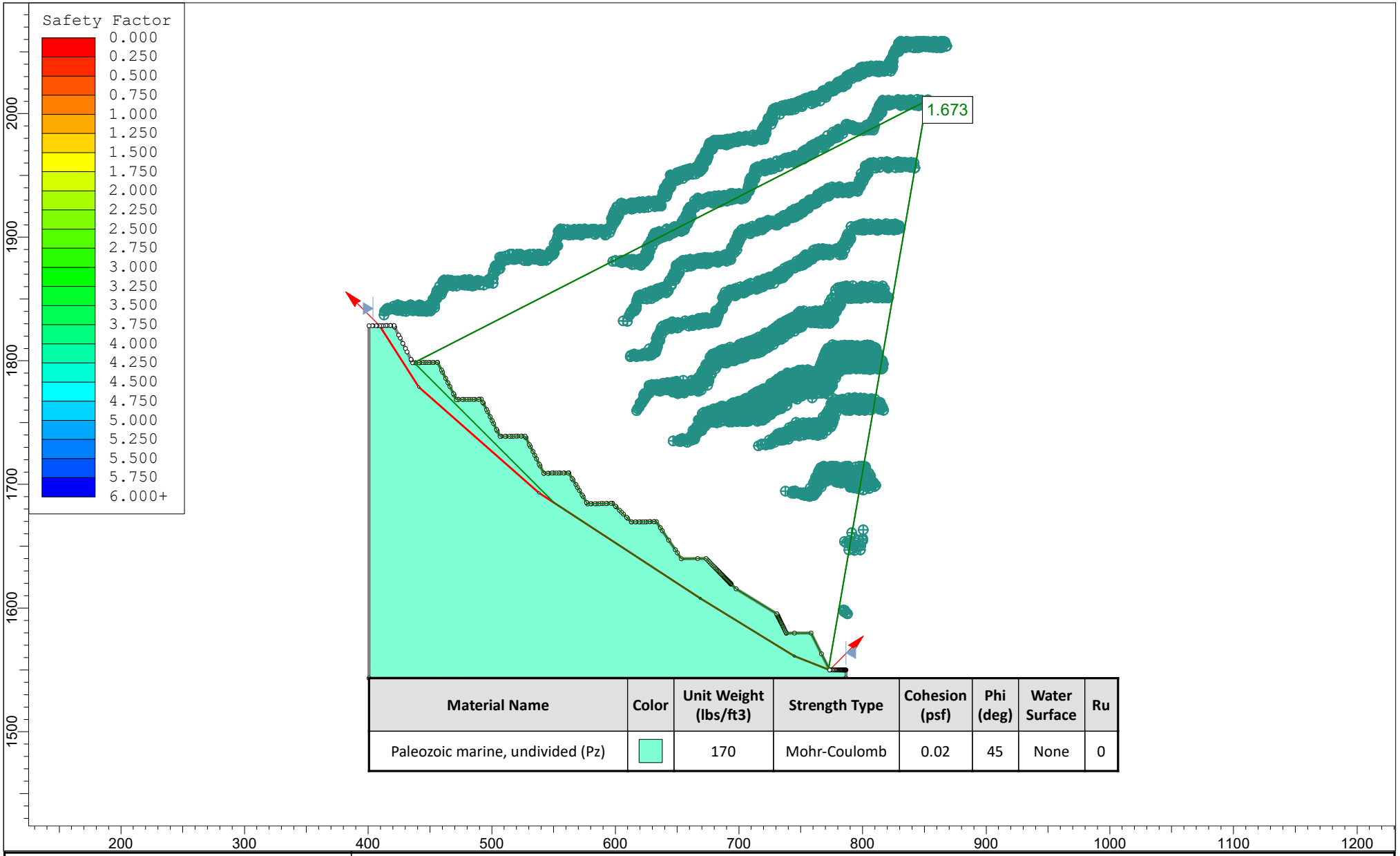
SLIDEINTERPRET 6.039

Project	Waddell Rock Quarry T-2		
Analysis Description	Rock Block Analysis		
Drawn By	James Fitzgerald	*Company*	GSI
Date	11/20/2022	*File Name*	Waddell_Rx_Pit_Rx_Slope_Stab_T2.slim

********** Summary **********

Slope Height = 310
Slope Face Angle = 36
Upper Slope Angle = 25
Cohesion = 0
Friction Angle = 40
Discontinuity Angle = 27
Unit Weight of Rock = 175
Unit Weight of Water = 64
Crest Location = 426.68
Discontinuity Length = 2883.52
Weight of Rock Block = 20816427.2

Stability Factor = 1.647



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Paleozoic marine, undivided (Pz)		170	Mohr-Coulomb	0.02	45	None	0

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SLIDEINTERPRET 6.039

Project	Waddell Rock Quarry T-3		
Analysis Description	Rock Block Analysis		
Drawn By	James Fitzgerald	*Company*	GSI
Date	11/20/2022	*File Name*	Waddell_Rx_Pit_Rx_Slope_Stab_T3.slim

********** Summary **********

Slope Height = 285
Slope Face Angle = 36
Upper Slope Angle = 25
Cohesion = 0
Friction Angle = 40
Discontinuity Angle = 27
Unit Weight of Rock = 175
Unit Weight of Water = 64
Crest Location = 392.27
Discontinuity Length = 2650.98
Weight of Rock Block = 17594321.6

Stability Factor = 1.647