



## **APPENDIX E**

### **SLOPE STABILITY DETERMINATION**



Proactive by Design

GEOTECHNICAL  
ENVIRONMENTAL  
ECOLOGICAL  
WATER  
CONSTRUCTION  
MANAGEMENT

20900 Swenson Drive  
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Waukesha, WI 53186  
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May 15, 2018  
File No. 20.0154893.10

Mr. Mathew Heath, HSE Manager  
Chippewa Sand Company, LLC  
105 Highway Q  
New Auburn, Wisconsin 54757

Re: Non-Metallic Mining Reclamation Slope Stability Analysis  
Chippewa Sand Company, LLC  
Chippewa County, Wisconsin

Dear Mr. Heath:

Pursuant to our recent discussions and correspondence, GZA GeoEnvironmental, Inc. (GZA) is pleased to submit this Non-Metallic Mining Reclamation Slope Stability Analysis to Chippewa Sand Company, LLC ("Client") for the industrial sand mine located in the Town of Cooks Valley, Chippewa County, Wisconsin ("Site").

#### BACKGROUND

A Site evaluation of the existing cut slopes was made on March 27, 2018, to record/observe the exposed mine slopes. On April 18, 2018, GZA submitted a *Slope Stability Determination* Memorandum, which is provided in Attachment 1, summarizing our findings and concluded that the proposed mine reclamation slopes will be safe and stable in accordance with industry-accepted methodologies. Per Wisconsin Administrative Code (WAC) NR 135.10 and Chippewa County 2007 Reclamation Standards for Non-Metallic Mines in Chippewa County, Appendix I, the mined slope completed in Spring 2012, qualified as a field test plot and demonstrates the Wonewoc Formation will remain stable with cut slopes ranging between 1.5H:1V and 1H:1V.

GZA recommended that the unconsolidated overburden slopes not be graded steeper than 3H:1V and the Tunnel City Group bedrock slopes not be cut steeper than 2H:1V. The recommended 3H:1V cut slope in the overburden is considered conservative and is flatter than the typical 2.5H:1V that the Wisconsin Department of Transportation (WisDOT) uses for most cut earth slope projects and is considered stable in nearly every circumstance.<sup>1</sup> For bedrock slopes, pre-splitting, precise ripping, or scaling is done to form the required slope inclination of the proposed face of the bedrock cut to produce a clean, neat bedrock face that will stand at slopes of ¼H:1V or less.<sup>2</sup> To effectively maintain a high-angle slope, the bedrock mass must be uniform and have few fractures and joints, as is the case with the Wonewoc Sandstone. In addition to the Chippewa Sand Company, LLC mine and other similar Wonewoc Sandstone mines in Wisconsin, WisDOT has effectively created stable high-angle slopes along highways in west-central Wisconsin, including in Eau Claire County.

Chippewa County Land Conservation and Forest Management reviewed GZA's *Slope Stability Determination* Memorandum and in a May 1, 2018 correspondence to Client, is now requesting that the analysis be completed "using Slope/w modeling software, or other industry accepted methodology." Although GZA's analysis concluded that the proposed mine reclamation slopes will be safe and stable, and the analysis was performed in accordance with industry-accepted

<sup>1</sup> Wisconsin Department of Transportation, Geotechnical Manual, Chapter 5 Roadway Investigations, Section 4 Level 3 Investigations and Reports. <http://wisconsindot.gov/Documents/doing-bus/eng-consultants/cnslt-rsrcs/geotechmanual/gt-05-04.pdf>.

<sup>2</sup> Ibid.



methodologies, GZA performed additional analysis to corroborate our initial findings. Note that this report should be reviewed with our April 18, 2018, *Slope Stability Determination* Memorandum.

## SLOPE STABILITY

A typical mine reclamation section was modeled for global stability analysis with SLOPE/W © Version 8.16 by Geo-Slope International, Ltd. Spencer's Method, a force-moment equilibrium analysis, was used to compute the theoretical factor of safety. The unconsolidated overburden material (sand with varying silt, clay, and gravel content) strength envelope was determined using Mohr-Coulomb theory to define the shear strength of the soil with a friction angle of 32°. The consolidated Tunnel City Group, Wonewoc Formation, and Eau Claire Formation strength envelopes were determined using the Hoek-Brown (1997) method using geological strength index properties based on geological descriptions. Consolidated (bedrock) material strength values derived from the Hoek-Brown criterion were applied to the 2-dimensional limit equilibrium slope stability analysis. Summary tables of the material strength models used for the stability analysis are attached in Figures 1, 2, and 3.

## RESULTS

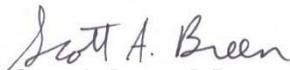
The stability of the proposed reclamation slopes was evaluated within the unconsolidated overburden layer and globally within the combined unconsolidated and consolidated (bedrock) material to the base of the mine. The global stability search routine extended below the mine base (floor) level; however, instability was not observed below the mine floor level. Slope stability modeling results indicate the proposed reclamation slopes will remain stable. Factor of Safety (FoS) against failure was greater than 2 for the isolated stability evaluation within the overburden and for the global stability evaluation of the combined unconsolidated and consolidated (bedrock) material. Graphical results of the global stability analyses are included in Figures 1, 2, and 3.

There is no Wisconsin or industry standard for factor of safety greater than 1.0 for a reclaimed mine rock slope. An industry standard for highways typically specify 1.5 as the minimum acceptable static factor of safety for cut, fill, and natural slopes. Safety factor is defined as the quotient of the sum of forces tending to resist failure divided by the sum of forces tending to cause failure. Also, the Slope/W modeling described above corroborated GZA's April 18, 2018, *Slope Stability Determination* Memorandum, both of which were completed in accordance with industry-accepted methodologies. The analyses concluded that the proposed mine reclamation slopes will be safe and stable with factors of safety greater than 2.0.

We appreciate the opportunity to submit the findings in this letter. Please feel free to contact the undersigned at (262) 754-2565 or [mark.krumenacher@gza.com](mailto:mark.krumenacher@gza.com) with any questions.

Very truly yours,

**GZA GeoEnvironmental, Inc.**

  
Scott A. Breen, P.E.  
Senior Consultant

  
Mark J. Krumenacher, P.G.  
Senior Vice President/Senior Principal

  
Michael A. DeVasto, P.G.  
Assistant Project Manager

  
John M. Siwula, P.E., D. GE  
Associate Principal

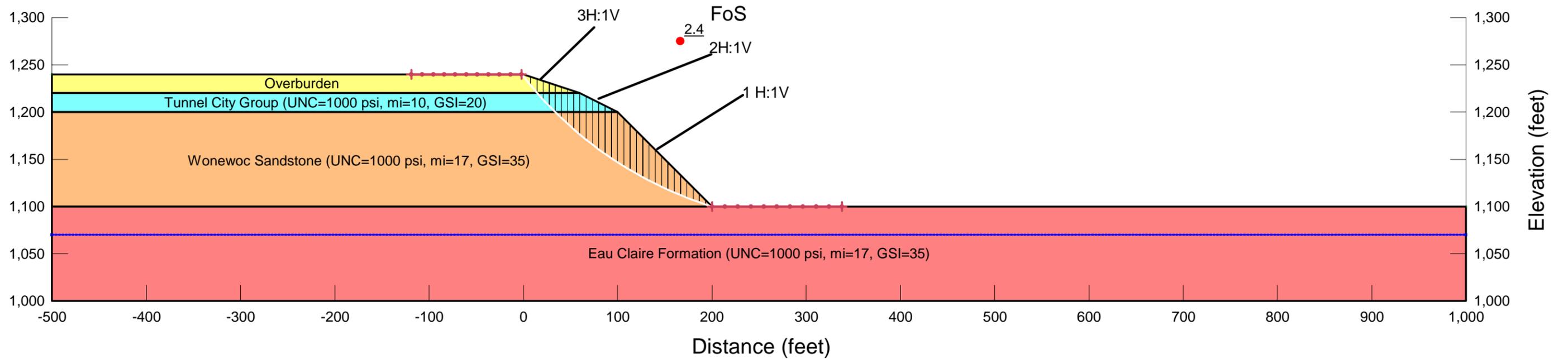
J:\154800to154899\154893 Chippewa Sand\2018 Stability Evaluation\Slope Stability\FINAL 154893.10 Slope Stability Analysis\_Chippewa Sand 5-15-18.docx

Attachments: Figures 1, 2, and 3  
April 18, 2018, *Slope Stability Determination* Memorandum



## FIGURES

# Figure 1

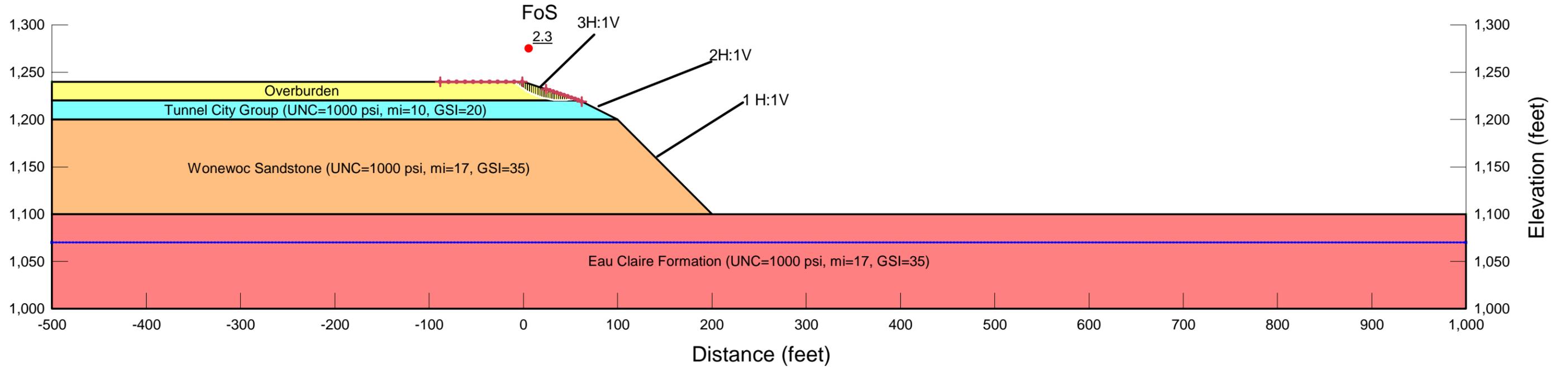


Color	Name	Model	Unit Weight (pcf)	Strength Function	Piezometric Line	Cohesion' (psf)	Phi' (°)
	Eau Claire Formation (UNC=1000 psi, mi=17, GSI=35)	Shear/Normal Fn.	150	Hoek-Brown Eau Claire Formation	1		
	Overburden	Mohr-Coulomb	120		1	0	32
	Tunnel City Group (UNC=1000 psi, mi=10, GSI=20)	Shear/Normal Fn.	150	Hoek-Brown Tunnel City Group	1		
	Wonewoc Sandstone (UNC=1000 psi, mi=17, GSI=35)	Shear/Normal Fn.	145	Hoek-Brown Wonewoc	1		



Proposed Reclamation Slopes (Global)	
Chippewa Sand Reclamation Slopes.gsz	
5/3/2018	1:1,300

# Figure 2



Color	Name	Model	Unit Weight (pcf)	Strength Function	Piezometric Line	Cohesion' (psf)	Phi' (°)
	Eau Claire Formation (UNC=1000 psi, mi=17, GSI=35)	Shear/Normal Fn.	150	Hoek-Brown Eau Claire Formation	1		
	Overburden	Mohr-Coulomb	120		1	0	32
	Tunnel City Group (UNC=1000 psi, mi=10, GSI=20)	Shear/Normal Fn.	150	Hoek-Brown Tunnel City Group	1		
	Wonewoc Sandstone (UNC=1000 psi, mi=17, GSI=35)	Shear/Normal Fn.	145	Hoek-Brown Wonewoc	1		



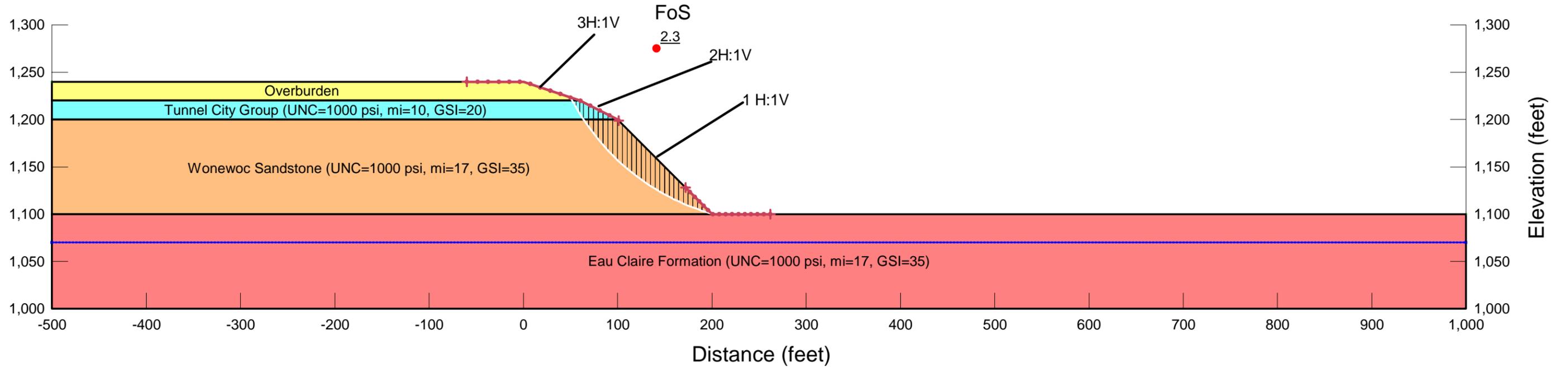
Proposed Reclamation Slopes (Overburden)

Chippewa Sand Reclamation Slopes.gsz

5/3/2018

1:1,300

# Figure 3



Color	Name	Model	Unit Weight (pcf)	Strength Function	Piezometric Line	Cohesion' (psf)	Phi' (°)
	Eau Claire Formation (UNC=1000 psi, mi=17, GSI=35)	Shear/Normal Fn.	150	Hoek-Brown Eau Claire Formation	1		
	Overburden	Mohr-Coulomb	120		1	0	32
	Tunnel City Group (UNC=1000 psi, mi=10, GSI=20)	Shear/Normal Fn.	150	Hoek-Brown Tunnel City Group	1		
	Wonewoc Sandstone (UNC=1000 psi, mi=17, GSI=35)	Shear/Normal Fn.	145	Hoek-Brown Wonewoc	1		



Proposed Reclamation Slopes (Consolidated)

Chippewa Sand Reclamation Slopes.gsz

5/4/2018

1:1,300



**ATTACHMENT 1**

**April 18, 2018, *Slope Stability Determination* Memorandum**



Proactive by Design

GEOTECHNICAL  
ENVIRONMENTAL  
ECOLOGICAL  
WATER  
CONSTRUCTION  
MANAGEMENT



## MEMORANDUM

**Date:** April 18, 2018

**To:** Mathew Heath, Chippewa Sand Company

**From:** Scott A. Breen, P.E., GZA GeoEnvironmental, Inc.  
Mark J. Krumenacher, P.G., GZA GeoEnvironmental, Inc.

**Re:** Slope Stability Determination  
Chippewa Sand Company Operations  
Chippewa County, Wisconsin

**Project No.:** 20.0154893.10

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GZA GeoEnvironmental, Inc. (GZA) is pleased to submit this Memorandum to Chippewa Sand Company ("Client") for the above referenced project. This Memorandum provides our findings and comments related to slope stability determination for the mining operations located in Chippewa County ("Site"), Wisconsin. Please note that this Memorandum is subject to the Limitations provided in *Attachment 1*.

### BACKGROUND

It is our understanding that the Land Conservation & Forest Management Department of Chippewa County is asking for a determination that the existing mined slopes are stable in their current configuration which will be similar to proposed conditions in the mine reclamation plan.

Mining at the Site is being performed using Caterpillar D8 and D9 dozers equipped with ripper teeth. The dozers make successive passes while ripping through the formations until the lowest mined elevation is reached. The exposed mine slopes are formed when the dozers back up to the planned cut line, lower their ripping teeth and rip towards the inside mined area in successive passes. The operating weights of the Caterpillar D8 and D9 are approximately 90,000 pounds (lbs) and 110,000 lbs, respectively.

### OBSERVATIONS

A Site evaluation of the existing cut slopes was made on March 27<sup>th</sup>, 2018, to record/observe the exposed mined slopes. The generalized profile of the observed mined slopes was estimated to consist of approximately 10 to 20 feet of overburden material (sand with varying silt, clay and gravel content), underlain by 10 to 20 feet of the Tunnel City Group Sandstone, underlain by the Wonewoc Sandstone Formation which extended to the base mined elevation.

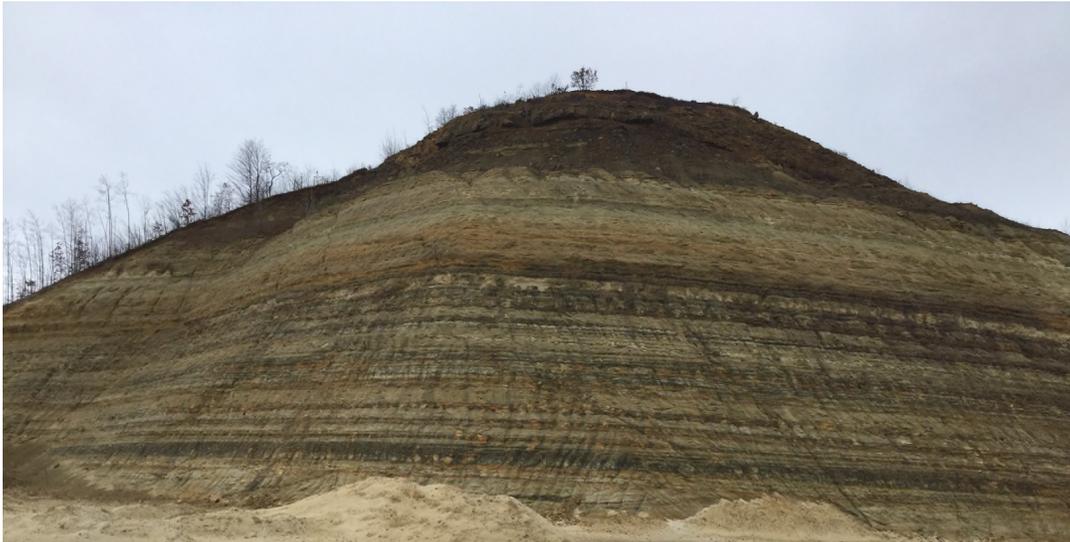
Based on information provided by the Client, the current cut slopes are approximately between 1.5 horizontal to 1 vertical (1.5H:1V) and 1 horizontal to 1 vertical (1H:1V) slopes from the surface of the overburden to the base mined elevation.

Two areas of the mine Site were specifically observed and compared from a stability perspective. One area is where the mined slope was completed in Spring of 2012 (*Photo No. 1 below*) and the other area is where the mined slope was completed in Summer of 2017 (*Photo No. 2 below*). No difference in the performance and stability of the Wonewoc Formation, which makes up the majority



of the mined slope, was observed from the cut completed in 2012 versus the cut completed in 2017. However, minor erosion of the overburden and slight raveling of the Tunnel City Group into the mined area was noted. The approximate locations of the Photo Nos. 1 and 2 are illustrated in *Attachment 2*, Figure 1.

**Photo No. 1: West Mine Cut – Completed Spring 2012**



**Photo No. 2: North Mine Cut – Completed Summer 2017**



## RECOMMENDATIONS

Wisconsin Administrative Code NR 135.10 and Chippewa County 2007 Reclamation Standards for Non-Metallic Mines in Chippewa County, Appendix I indicate an operator may perform a field test plot to demonstrate a stable and safe condition of a mined slope will be achieved, and that post-mining land use specified in the reclamation plan will not be adversely affected. The mined slope, shown in the above *Photo No. 1*, completed in Spring of 2012 qualifies as a field test plot and demonstrates the Wonewoc Formation will remain stable with cut slopes ranging between 1.5H:1V and 1H:1V.



Also, per Wisconsin Administrative Code and Chippewa County Standards, reclaimed slopes of the unconsolidated materials (overburden) are recommended to not be graded steeper than 3H:1V and properly stabilized with vegetation per the reclamation plan. Due to potential raveling, the Tunnel City Group should be evaluated at the time of the final mining cut for stability by the Engineer for recommendations based on the bedrock condition at that time. For reclamation planning purposes, final reclaimed slopes of the Tunnel City Group are recommended to not be cut steeper than 2H:1V. A detail of the minimum recommended reclamation slopes is included in *Attachment 2*, Figure 2.

If you have questions regarding this information, please contact us.

J:\154800to154899\154893 Chippewa Sand\2018 Stability Evaluation\20.0154893.10 Memo-Highwall Slopes 04-18-18.docx

Attachments: Limitations  
Figure 1 - Test Plot Photo Locations  
Figure 2 - Recommended Minimum Reclamation Slopes



## **ATTACHMENT 1**

### **Limitations**



## **GEOTECHNICAL LIMITATIONS**

### Use of Memorandum

1. GZA GeoEnvironmental, Inc. (GZA) prepared this memorandum on behalf of, and for the exclusive use of Chippewa Sand Company ("Client") for the stated purpose(s) and location(s) identified in the proposal for services and/or memorandum. Use of this memorandum, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not expressly identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

### Standard of Care

2. GZA's findings and conclusions are based on the work conducted as part of the Scope of Services set forth in the proposal for services and/or memorandum and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. If conditions other than those described in this memorandum are found at the subject location(s) or the design has been altered in any way, GZA shall be so notified and afforded the opportunity to revise the memorandum, as appropriate, to reflect the unanticipated changed conditions.
3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

### Subsurface Conditions

4. The generalized soil profile(s) provided in our memorandum are based on information provided by the Client and are intended only to convey trends in subsurface conditions. The composition of strata and the transitions between strata may be more variable and more complex than indicated.
5. In preparing this memorandum, GZA relied on certain information provided by Client, state and local officials, and other parties referenced therein which were made available to GZA at the time of our evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.
6. GZA's services did not include an assessment of the presence of oil or hazardous materials at the property. Consequently, we did not consider the potential impacts (if any) that contaminants in soil or groundwater may have on construction activities or the use of structures on the property.

### Compliance with Codes and Regulations

7. GZA used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various and possibly contradictory interpretations. Compliance with codes and regulations by other parties is beyond our control.

### Additional Services

8. GZA recommends that we be retained to provide services during any future site observations, design, implementation activities, construction and/or property development/redevelopment. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.



## **ATTACHMENT 2**

### **Figures**

©2018 - GZA GeoEnvironmental, Inc. GZA-J:\154800\154899\154893 CHIPPEWA SAND\DRAWINGS\GZA CAD\2017DEC\_CHIPPEWA SITE PLAN.DWG 7 APRIL 9, 2018 KARA KOCH

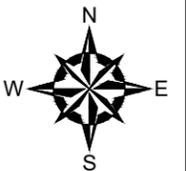
**LEGEND**

- APPROXIMATE SITE BOUNDARY
- PHOTO LOCATIONS

**Photo No. 2: North Mine Cut – Completed Summer 2017**



**Photo No. 1: West Mine Cut – Completed Spring 2012**



NO.	ISSUE/DESCRIPTION	BY	DATE

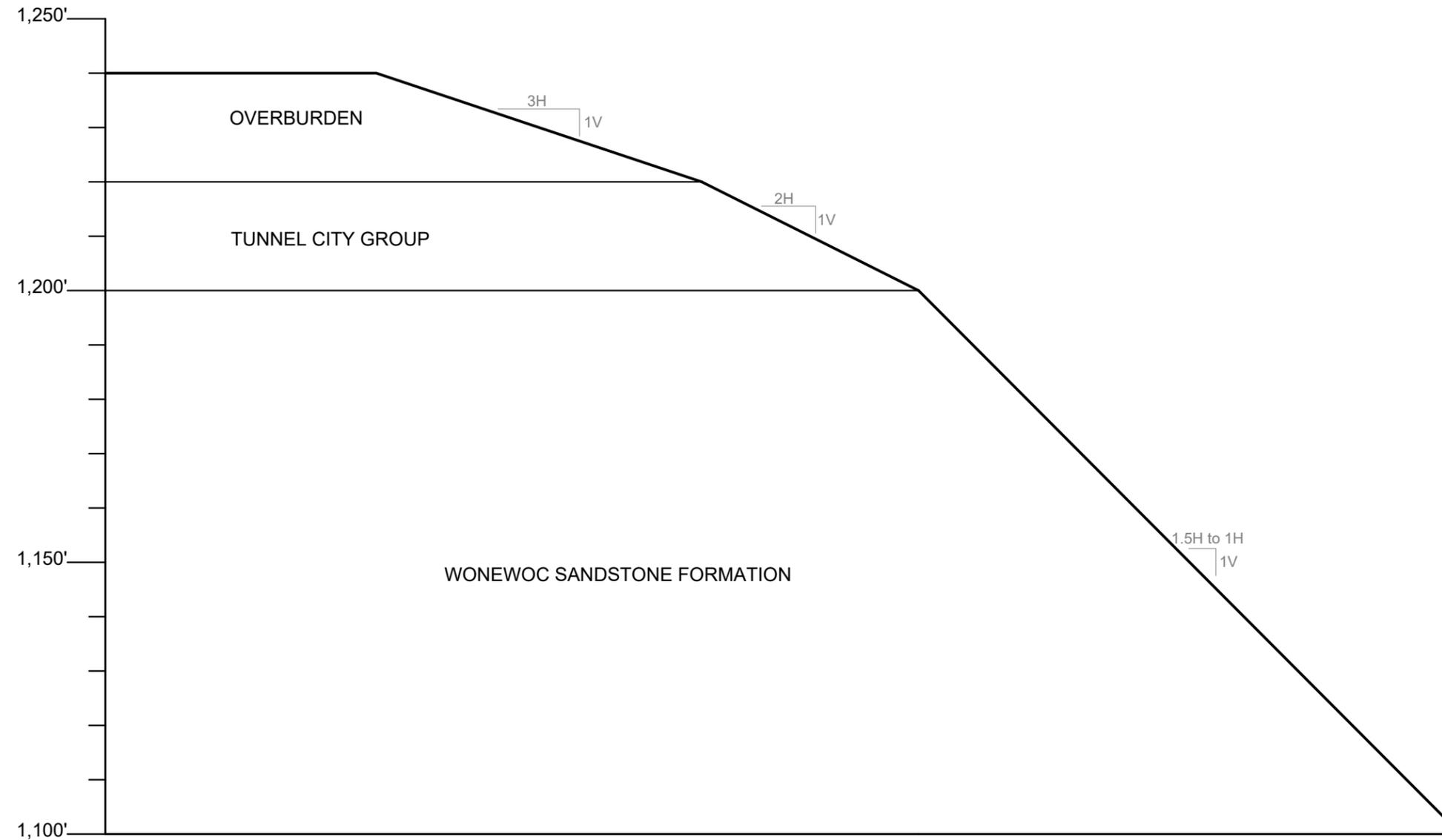
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**CHIPPEWA SAND COMPANY RECLAMATION PLAN**  
 3244 COUNTY HWY A  
 BLOOMER, WI 54724

**PHOTO LOCATION SITE PLAN**

PREPARED BY: <b>GZA GeoEnvironmental, Inc.</b> Engineers and Scientists www.gza.com	PREPARED FOR: CHIPPEWA SAND COMPANY LLC
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PROJ MGR: SAB	REVIEWED BY: SAB	CHECKED BY: MJK	FIG
DESIGNED BY: SAB	DRAWN BY: LES	SCALE: see above	1
DATE: 4/10/18	PROJECT NO. 20.0153893	REVISION NO.	



NO.	ISSUE/DESCRIPTION	BY	DATE

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CHIPPEWA SAND COMPANY RECLAMATION PLAN  
3244 COUNTY HWY A  
BLOOMER, WI 54724

**RECOMMENDED MINIMUM  
RECLAMATION MINE SLOPE**

PREPARED BY:  <b>GZA</b> GeoEnvironmental, Inc. Engineers and Scientists www.gza.com	PREPARED FOR: CHIPPEWA SAND COMPANY LLC
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PROJ MGR: SAB	REVIEWED BY: SAB	CHECKED BY: MJK	FIG
DESIGNED BY: SAB	DRAWN BY: LES	SCALE: not to scale	2
DATE: APRIL 2018	PROJECT NO. 20.0154893.10	REVISION NO.	